PUBLIC DOCUMENT . . . . . No. 31.

FORTY-SECOND ANNUAL REPORT

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1905.

BOSTON:
WRIGHT & POTTER PRINTING CO., STATE PRINTERS,
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Approved by

The State Board of Publication.

Commonwealth of Massachusetts.

Massachusetts Agricultural College,
Amherst, Jan. 3, 1905.

To His Excellency John L. Bates.

Sir: — I have the honor to transmit herewith, to Your Excellency and the Honorable Council, the forty-second annual report of the trustees of the Massachusetts Agricultural College.

I am, very respectfully, your obedient servant,

HENRY H. GOODELL,
President.

CONTENTS.

CALENDAR FOR 1905–1906.

Jan. 4, 1905, Wednesday, fall semester resumed, at 8 A.M.
February 8, Wednesday, fall semester ends.
February 9, Thursday, spring semester begins, at 8 A.M.
March 29, Wednesday, to April 4, Tuesday, } spring recess.
April 4, Tuesday, spring semester resumed, at 8 A.M
June 17, Saturday, Grinnell prize examination of the senior class in agriculture.
June 18, Sunday, Baccalaureate sermon.
June 19, Monday, { Burnham prize speaking / Flint prize oratorical contest.
June 20, Tuesday, { Class-day exercises. / Meeting of the alumni. / Reception by the president and trustees.
June 21, Wednesday, commencement exercises.
June 22, 23, Thursday and Friday, examinations for admission, at 9 A.M., Botanic Museum, Amherst; at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; at Pittsfield: and at Horticultural Hall, Worcester.
September 19, 20, Tuesday and Wednesday, examinations for admission, at 9 A.M., Botanic Museum.
September 21, Thursday, fall semester begins, at 8 A.M.
December 20, Wednesday, to Jan. 3, 1906, Wednesday, } winter recess.
January 3, Wednesday, fall semester resumed, at 8 A.M.
February 7, Wednesday, fall semester ends.
February 8, Thursday, spring semester begins, at 8 A.M.
March 28, Wednesday, to April 3, Tuesday, } spring recess.
April 3, Tuesday, spring semester resumed, at 8 A.M.
June 20, Wednesday, commencement exercises.

ANNUAL REPORT OF THE TRUSTEES

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

His Excellency the Governor and the Honorable Council.

It has frequently been said that, if the people of this Commonwealth half realized the advantages offered their sons and daughters at the Massachusetts Agricultural College, it would be filled to overflowing. The past year has come nearer realizing this statement than any other, and yet an analysis of the annual report shows how far away we still are from reaching this happy condition, even though we have entered upon its very threshold. There are, roughly speaking, about 350 towns and cities in this State, and there ought to be at least an approximate representation from each one of these centres of population; instead of that, we find barely a 37 per cent. representation. We find our 273 students distributed among 130 towns, as follows: —

Abington,	1	Cochituate,	1
Amesbury,	1	Cohasset,	1
Amherst,	21	Concord,	1
Andover,	1	Curtisville,	1
Ashburnham,	1	Dana,	1
Attleborough,	1	Dedham,	1
Barre,	2	Deerfield,	1
Becket,	1	Dorchester,	1
Belchertown,	4	Easton,	2
Belmont,	1	East Brewster,	1
Bernardston,	2	East Charlemont,	1
Boston,	4	East Northfield,	1
Brimfield,	1	East Pepperell,	2
Brockton,	7	Egremont,	1
Brookfield,	2	Falmouth,	1
Cambridge,	1	Fall River,	2
Campello,	1	Florence,	2
Canton,	1	Framingham,	1
Cheshire,	1	Goshen,	1

Granby,	1	Peabody,	1
Greenwich Village,	1	Pepperell,	2
Hadley.	3	Petersham,	1
Halifax,	1	Pittsfield,	2
Hinsdale,	1	Plainfield,	1
Holliston,	1	Reading,	1
Hopedale,	3	Richmond,	2
Hudson,	1	Rockland,	2
Hyde Park,	2	Roslindale,	1
Jamaica Plain,	2	Roxbury,	3
Lancaster,	2	Rutland,	1
Lee,	1	Salem,	2
Lenox,	1	Saugus,	1
Leominster,	1	Scituate,	1
Lexington,	1	Sherborn,	1
Lincoln,	1	Somerville,	6
Littleton,	1	South Amherst,	2
Long Plain,	1	South Boston,	1
Lowell,	3	Southborough,	1
Ludlow,	1	Southbridge,	1
Lynn,	2	South Framingham,	1
Malden,	4	South Hadley,	1
Marlborough,	1	South Natick,	1
Marshfield,	1	Southwick,	2
Maynard,	1	Spencer,	1
Medford,	1	Springfield,	4
Melrose Highlands,	1	Sterling,	1
Middleborough,	1	Stockbridge,	1
Milford,	1	Stoughton,	2
Millbury,	6	Sunderland,	2
Millis,	2	Swampscott,	3
Monson,	1	Taunton,	1
Montague,	1	Templeton,	1
Natick,	6	Tewksbury,	1
Newburyport,	1	Townsend,	2
New Dorchester,	1	Waltham,	4
Newton,	2	Westborough,	3
Newtonville,	3	West Dracut,	1
North Amherst,	2	Westfield,	2
North Brookfield	1	Westford,	2
Northampton,	1	West Millbury,	1
Northfield,	1	West Roxbury,	1
North Gratton,	1	Wilkinsonville,	1
North Hadley,	1	Winchester,	1
Orange,	1	Winthrop,	2
Osterville,	2	Worcester,	9

China, Barbados and Japan furnish 1 each; the remaining 36 are distributed in the following States: Connecti-

cut, Illinois, Kansas, New Hampshire, New York, New Jersey, Vermont, Tennessee, Iowa, Maine, California, Georgia.

It seems difficult to secure a foothold in the west and north-west portions of the State, and perhaps it is fortunate that it was so this year, for the attendance has been so large that it has been found impossible to give the students the education offered them in our report. In the senior and graduate classes we have been compelled to refuse 3 students for lack of room in the entomological department, and next year the pressure will be still greater. In the horticultural department we have had to simply say to the junior class, "We cannot give you the education promised, — our accommodations are too small;" and next year we shall find ourselves confronted with a still worse condition of affairs. Our freshman class has suffered the most, for we have been compelled to divide it into three sections, and to debar the last (25 men) from work in botany. How it can ever be made up I do not see, without increased facilities in room and equipment. Your committees, last year, reported a bill advocating increased accommodations, but it did not seem wise to press it. We return this year, asking that you will supply us with the means to adequately furnish the education required by our charter and the laws of this Commonwealth. It is a matter of absolute necessity, and does not admit of any delay. Before this, some kind of provision could be made; but with entering classes of 70 and 80 it is now quite impossible, and means one of two things, — either retrogression and frankly disowning a portion of the course, or else attempting to carry it on in a half-hearted way, — a source of shame to ourselves and a constant element of discontent to the student.

The botanical, horticultural and entomological departments demand immediate assistance. The last mentioned can be easiest and most quickly reached by increasing the length of the building, and repairing the greenhouse used in connection with breeding and destroying insects, at a cost of say $3,000. The kind of work in which the students are engaged here is mostly microscopic, and necessitates individually more room and more light than in the ordinary

recitation room. These two features, for a limited number, can be secured in the manner above indicated.

For the horticultural department an entirely new building, exclusive of its greenhouse, can be erected and equipped at a cost not to exceed $40,000, and $1,000 annual maintenance fund. This will provide for all classes in market gardening, horticulture, floriculture, greenhouse management and landscape gardening, and relieve the congested condition of the botanical department. A fine building, 50 by 70 feet, one story and a half on its front and three on its rear, containing laboratory, photographing rooms, landscape gardening and recitation rooms, can be put up for the sum mentioned. This building is a necessity. The only room the department now can call its own is the botanic museum, where all specimens have been made useless by being pushed back to the wall, to allow room for tables, seats and other equipment.

We have said that $40,000 would put up, equip and properly furnish a brick building, as nearly fireproof as may be, for carrying on the work of this department. The different items tabulate as follows: —

Building,	$29,000
Heating,	3,000
Grading and roads,	1,500
Furnishing and equipment,	4,500
Electric lights,	500
Architects' fee,	1,450
Total,	$39,950

But in addition to these items is the one most important of all, — a modern greenhouse, for the purpose of teaching the growing of crops from the commercial standpoint. If this cannot be taught, then we shall have deplorably failed in all our instruction. The whole object of the investigations of the great father of philosophy was *utility*, and from his day on to this the world has gone on advancing, and its condition has been improving. A greenhouse not costing over $14,600, and including salesroom and heating, is needed for the practical demonstration of growing for the market flowers and market-gardening stuffs.

The botanical department has for thirty-seven years been handicapped by everything belonging to any other department for which room could not be found elsewhere. It has gladly given shelter to zoölogy, entomology, physiology, geology, and, in fact, to most of the natural sciences it has shown itself a tender mother. Last to ask anything for itself, it has nearly the same old equipment of two-score years ago. Everything has been outgrown, and the demands upon it far exceed its available resources. With rooms, at a maximum, furnishing room and accommodation and apparatus for 30, it now has classes of 75 to 80, with every prospect of increase in the coming years. To provide not only for the necessities of the present, but to look ahead and see that the possibilities of the future are supplied, is the problem that confronts us. It has seemed wiser to group together the buildings of the station and college, in order that the teacher may take advantage of the investigations of the experimenter. This building, then, although absolut ly distinct, partakes rather of an addition to the botanical division of the experiment department than to a separate building. It provides for teaching the botany of all the undergraduate as well as the graduate classes. It provides laboratory room, double the capacity of that at present employed. It furnishes lecture rooms for audiences of at least 150, and, most important, presents an up-to-date building, equipped with the most modern appliances and instruments for prosecuting the study of botany. For the erection and equipment of this building there will be required an outlay of $35,900, and an annual maintenance fund of $1,000.

Summing up briefly our needs, we require for the —

Entomological division,	$3,200
Horticultural: —	
Building,	29,000
Heating,	3,000
Grading and roads,	1,500
Furnishing and equipment,	4,500
Architects' fee,	1,450
Electric lights,	500
Greenhouse,	14,600
Annual maintenance fund,	1,000

Botanical: —	
Building and equipment,	$35,900
Annual maintenance fund,	1,000
For duplicate generator of heating and lighting plant, not to exceed	5,000
For painting barn,	1,000
For improvement of live stock,	5,000
For extending heating and lighting plant to vegetable pathology and horticultural buildings,	8,500

In accordance with the Acts and Resolves of the General Court, 1904, creating a forester, it was made one of his duties to deliver a course of lectures at the Massachusetts Agricultural College. It is briefly outlined by State Forester Akerman as follows: —

This is a course of twelve lectures on the art and science of forestry, to be given by the State Forester, in accordance with the statute which established his office. The first five of these lectures will deal with forestry in general, its scope and meaning to civilization; the remaining lectures will be on problems presented by the forest conditions of this Commonwealth, and especially those which arise in connection with farm wood lots. The college wood lot will be used to illustrate some of the subjects dealt with in the lectures. The course is to be given in the early months of the year.

The college exhibit made at the St. Louis fair was participated in by the departments of agriculture, botany, entomology, horticulture, chemistry, veterinary and English, and was intended to show the work of college and station. It seems to have been a success, for the *grand prix* was awarded us. The different articles of exhibit were as follows: —

First. — Each of the departments mentioned contributed a set of photographs, illustrating buildings, lecture rooms and laboratories, and the equipment used in its work. The literary work of the alumni of the college was shown by as complete an exhibit as could be brought together of the books which have been published by alumni. This exhibit included about thirty volumes, treating a considerable variety of subjects; a large proportion pertained

to agriculture, or the sciences closely connected therewith.

Second. — Aside from the general material which has already been mentioned, a number of the departments were represented by special exhibits. The more important features of the exhibit made by each will be made clear by the following statement: —

Agricultural Department. — This department exhibited a large number of specimen sheaves and preserved plants and seeds of the more important crops of the State. Especially prominent were those which were introduced into the United States by the head of the department.

The methods and results of an experiment to determine the relative availability of fertilizers were shown in facsimile by means of artificial plants made to scale, set into the pots actually used in the experiments.

The results of an experiment in feeding hens for eggs were shown by two parallel series of glass jars and cases, in which the contrasted methods of feeding were made clear by showing the different foods in layers. The basis adopted was the average requirements and product of one hen for one month. Besides the actual foods, the exhibit showed the total of nutrients contained in the foods used under the two systems, the number of eggs laid by a single hen in one month under each system of feeding, and the total of the nutrients given in the foods recovered in the eggs.

The results of an experiment with fertilizers in the field were shown to exact scale in high and narrow glass jars, eight in number, each containing the product in shelled corn of one thousandth part of an acre.

Horticultural Department. — Some idea of the nature of the work in this department along educational lines was afforded by means of a collection of drawings, some twenty in number, prepared by students as a regular feature of their work. A line of investigation in which the department has been especially prominent was represented by means of a collection of specimens showing variation in the nature of graft unions. The department also exhibited a collection of wax models, designed to show the originals from which each

of the various cultivated fruits has been developed, and the different highly improved forms which have been produced from these originals.

Department of Botany and Vegetable Pathology. — This department showed a large collection of apparatus employed in determining the percentage of germination of seeds, apparatus which has been used in studying the effect of electricity on the germination of seeds, and models of a number of different types of apparatus employed in sterilizing the soil in greenhouses for prevention of disease. The department showed also a large number of specimens illustrating the effects of fungous diseases. A part of these were mounted in gelatine held between plates of glass, — a method which has been perfected in the department, and which preserves the color and natural appearance in a very perfect manner; while a portion of the specimens had been dried, pressed and mounted on cotton. The department also showed a collection including many of the important mushrooms, represented by means of beautifully made paper models; there were three dozen specimens in this collection.

Department of Entomology. — This department showed eight glass-topped trays of insects, illustrating the following educational topics: —

I. Life history of the gypsy moth: its parasites and insect enemies.

II. Life history of the brown-tail moth: its parasites and insect enemies.

III. Examples of cases of the mimicry of one insect by another, occurring in Massachusetts.

IV. Examples of cases of the imitation of various objects, such as twigs, bark, etc., by insects.

V. The modern ideas as to the genealogy and relation to each other of the different groups of insects, with specimens of each group.

VI. Specimens showing differences of form, color or markings in the sexes (antigeny).

VII. A complete life history of the apple tree tent caterpillar, showing the meaning of a life history.

VIII. Specimens of our chief insect pests, showing which are native to this country and which are introduced.

Chemical Department. — The exhibit of this department filled a large case, and was designed to illustrate educational methods of research in the department. The exhibit included a large number of specimens of chemical compounds prepared in the laboratory.

Veterinary Department. — The exhibit of this department included a large number of models and especially prepared specimens used in illustrating the anatomy of each of the various domestic animals. Many of the prepared specimens were the work of students or alumni of the college.

At the meeting of the trustees in Amherst, June 14, 1904, a committee was appointed to draft resolutions on the death of Charles L. Flint. The following tribute to Mr. Flint was presented to the trustees at their meeting on Jan. 3, 1905: —

Tribute to Charles Louis Flint.

In the death of Charles Louis Flint this Board has lost one of its most faithful members. Although quiet and unassuming in manner, he was forceful and resourceful in character. Always considerate, always honorable in his dealings with men, he won their respect and confidence. His father, a graduate of Harvard, and for many years secretary of this Board, gave his two sons their choice between the Agricultural College at Amherst and Harvard College at Cambridge, hoping they would select the former, which they both did. Mr. Flint, our late associate, never regretted his choice, was always proud of his alma mater, and defended her on every and all occasions. He showed his good will in deeds as well as in kind words, for, when the time came to help the college, he established, and for several years maintained, the "Flint Rhetorical Prizes," which, along with the Burnham prizes, have accomplished so much for our English department. The college has indeed lost a loyal supporter and helpful friend, and this Board a quiet, modest, lovable, yet dignified associate.

We desire to record here our grateful remembrance of his wise generosity and thoughtful service to his alma mater, and to extend to his family our deep sympathy in the loss of a true husband and a devoted father.

His classmate and college chum, Dr. Hills of Vermont, paraphrasing another, wrote concerning him: "I believe that, while Mounts Holyoke, Tom and Toby have never occupied chairs in the faculty of this college, they have been as potent factors in the shaping of the character of its students as have many even of its best instructors; and I think I see their quiet, beauty, dignity and strength reflected in the character and life of our friend, Charles Louis Flint."

WILLIAM WHEELER,
W. H. BOWKER,
E. D. HOWE,
Committee.

Respectfully submitted, by order of the trustees,

HENRY H. GOODELL,
President.

AMHERST, Jan. 3, 1905.

THE CORPORATION.

	TERM EXPIRES
WILLIAM H. BOWKER of Boston,	1906
GEORGE H. ELLIS of Boston,	1906
J. HOWE DEMOND of Northampton,	1907
ELMER D. HOWE of Marlborough,	1907
NATHANIEL I. BOWDITCH of Framingham,	1908
WILLIAM WHEELER of Concord,	1908
ARTHUR G. POLLARD of Lowell,	1909
CHARLES A. GLEASON of New Braintree,	1909
JAMES DRAPER of Worcester,	1910
SAMUEL C. DAMON of Lancaster,	1910
MERRITT I. WHEELER of Great Barrington,	1911
CHARLES H. PRESTON of Danvers,	1911
WILLIAM R. SESSIONS of Springfield,	1912
M. FAYETTE DICKINSON of Boston,	1912

Members ex Officio.

His Excellency Governor JOHN L. BATES,
President of the Corporation.

HENRY H. GOODELL, *President of the College.*

GEORGE H. MARTIN, *Secretary of the Board of Education.*

J. LEWIS ELLSWORTH, *Secretary of the Board of Agriculture.*

WILLIAM R. SESSIONS of Springfield.
Vice-President of the Corporation.

J. LEWIS ELLSWORTH of Worcester, *Secretary.*

GEORGE F. MILLS of Amherst, *Treasurer.*

CHARLES A. GLEASON of New Braintree, *Auditor.*

Committee on Finance and Buildings.*

WILLIAM R. SESSIONS, J. HOWE DEMOND,
ARTHUR G. POLLARD, CHARLES H. PRESTON,
CHARLES A. GLEASON, *Chairman.*

Committee on Course of Study and Faculty.*

WILLIAM H. BOWKER, ELMER D. HOWE,
M. FAYETTE DICKINSON, GEORGE H. ELLIS,
WILLIAM WHEELER, *Chairman.*

Committee on Farm and Horticulture.*

Farm Division.

GEORGE H. ELLIS, N. I. BOWDITCH,
MERRITT I. WHEELER, WILLIAM R. SESSIONS, *Ch'man.*

Horticultural Division.

JAMES DRAPER, ELMER D. HOWE,
J. L. ELLSWORTH, *Chairman.*

Committee on Experiment Department.*

J. LEWIS ELLSWORTH, CHARLES H. PRESTON,
WILLIAM H. BOWKER, SAMUEL C. DAMON,
JAMES DRAPER, *Chairman.*

Committee on New Buildings and Arrangement of Grounds.*

WILLIAM WHEELER, SAMUEL C. DAMON,
M. FAYETTE DICKINSON, N. I. BOWDITCH,
JAMES DRAPER, *Chairman.*

Board of Overseers.

STATE BOARD OF AGRICULTURE.

---

* The president of the college is ex officio a member of each of these committees.

Examining Committee of Overseers.

JOHN BURSLEY (*Chairman*), . . . of West Barnstable.
C. K. BREWSTER, ... of Worthington.
W. C. JEWETT, ... of Worcester.
ARTHUR A. SMITH, ... of Colrain.
CHARLES H. SHAYLOR, . . of Lee.

The Faculty.

HENRY H. GOODELL, LL.D., *President*,
Professor of Modern Languages.

CHARLES A. GOESSMANN, Ph.D., LL.D.,
Professor of Chemistry.

CHARLES WELLINGTON, Ph.D.,
Associate Professor of Chemistry.

CHARLES H. FERNALD, Ph.D.,
Professor of Zoölogy.

Rev. CHARLES S. WALKER, Ph.D.,
Professor of Mental and Political Science.

WILLIAM P. BROOKS, Ph.D.,
Professor of Agriculture.

GEORGE F. MILLS, M.A.,
Professor of English and Latin.

JAMES B. PAIGE, D.V.S.,
Professor of Veterinary Science.

GEORGE E. STONE, Ph.D.,
Professor of Botany.

JOHN E. OSTRANDER, M.A., C.E.,
Professor of Mathematics and Civil Engineering.

HENRY T. FERNALD, PH.D.,
Professor of Entomology.

JOHN ANDERSON, MAJOR, U. S. A.,
Professor of Military Science and Tactics.

FRANK A. WAUGH, M.S.,
Professor of Horticulture and Landscape Gardening.

RICHARD S. LULL, PH.D.,
Associate Professor of Zoölogy.

PHILIP B. HASBROUCK, B.S.,
Associate Professor of Mathematics.
Adjunct Professor of Physics.

HERMAN BABSON, M.A.,
Assistant Professor of English and Instructor in German.

FRED S. COOLEY, B.Sc.,
Assistant Professor of Agriculture.
(Animal Husbandry and Dairying.)

SAMUEL F. HOWARD, B.Sc.,
Assistant Professor of Chemistry.

LOUIS R. HERRICK, B.Sc.,
Instructor in French and Spanish.

HENRY J. FRANKLIN, B.Sc.,
Instructor in Botany.

GEORGE O. GREENE, M.S.,
Instructor in Horticulture.

FRANCIS CANNING,
Instructor in Floriculture.

ROBERT W. LYMAN, LL.B.,
Lecturer on Farm Law.

E. FRANCES HALL,
Librarian.

RICHARD S. LULL, PH.D.,
Registrar.

ELWIN H. FORRISTALL, M.Sc.,
Farm Superintendent.

Graduates of 1904.*

Ahearn, Michael Francis,	Framingham.
Back, Ernest Adna (Boston Univ.),	Florence.
Blake, Maurice Adin,	Millis.
Couden, Fayette Dickinson,	Amherst.
Elwood, Clifford Franklin,	Green's Farms, Conn.
Fulton, Erwin Stanley,	Lynn.
Gilbert, Arthur Witter (Boston Univ.),	Brookfield.
Gregg, John William (Boston Univ.),	South Natick.
Griffin, Clarence Herbert,	Winthrop.
Haskell, Sidney Burritt,	Southbridge.
Henshaw, Fred Forbes,	Templeton.
Hubert, Zachary Taylor (Boston Univ.),	Pride, Ga.
Newton, Howard Douglas (Boston Univ.),	Curtisville.
O'Hearn, George Edmund,	Pittsfield.
Parker, Sumner Rufus,	Brimfield.
Peck, Arthur Lee (Boston Univ.),	Hartford, Conn.
Quigley, Raymond Augustine,	Brockton.
Raymoth, Reuben Raymond,	Goshen.
Staples, Parkman Fisher (Boston Univ.),	Westborough.
White, Howard Morgan,	Springfield.

Two-Years Course.

Hunt, Justine,	Newton.
Total,	21

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* The annual report, being made in January, necessarily includes parts of two academic years, and the catalogue bears the names of such students as have been connected with the college during any portion of the year 1904.

Senior Class.

Adams, Richard Laban,	Jamaica Plain.
Allen, George Howard,	Somerville.
Barnes, Hugh Lester,	Stockbridge.
Bartlett, Francis Alonzo,	Belchertown.
Crosby, Harvey Davis,	Rutland.
Cushman, Esther Cowles,	Amherst.
Gardner, John Joseph,	Milford.
Gay, Ralph Preston,	Stoughton.
Hatch, Walter Bowerman,	Falmouth.
Hill, Louis William Barlow,	Greenfield Hill, Conn.
Holcomb, Charles Sheldon,	Tariffville, Conn.
Hunt, Thomas Francis,	Amherst.
Hutchings, Frank Farley,	South Amherst.
Ingham, Norman Day,	Granby.
Kelton, James Richard,	Orange.
Ladd, Edward Thorndike,	Winchester.
Lewis, Clarence Waterman,	Melrose Highlands.
Lyman, John Franklin,	Amherst.
Munson, Willard Anson,	Aurora, Ill.
Newhall, Jr., Edwin White,	San Francisco, Cal.
Patch, George Willard,	Lexington.
Richardson, Justus Cutter,	West Dracut.
Sanborn, Monica Lillian,	Salem.
Sears, William Marshall,	Brockton.
Swain, Allen Newman,	New Dorchester.
Taylor, Albert Davis,	Westford.
Tompson, Harold Foss,	Jamaica Plain.
Tupper, Bertram,	Barre.
Walker, Lewell Seth,	Natick.
Whitaker, Chester Leland,	Somerville.
Williams, Percy Frederic,	Natick.
Willis, Grenville Norcott,	Becket.
Yeaw, Frederick Loring,	Winthrop.
Total,	33

Junior Class.

Carey, Daniel Henry,	Rockland.
Carpenter, Charles Walter,	Monson.
Chapman, George Henry,	New Britain, Conn.
Colton, William Wallace,	Pittsfield.

Craighead, William Hunlie,	Boston.
Ferren, Frank Augustus,	Peabody.
Filer, Harry Burton,	Belchertown.
French, George Talbot,	Tewksbury.
Gaskill, Edwin Francis,	Hopedale.
Hall, Jr., Arthur William,	North Amherst.
Hastings, Jr., Addison Tyler,	Natick.
Hayward, Afton Smith,	South Amherst.
Hood, Clarence Ellsworth,	Millis.
Jones, Louis Franklin,	Somerville.
Kennedy, Frank Henry,	South Boston.
Martin, James Edward,	Brockton.
Moseley, Louis Hale,	Glastonbury, Conn.
Mudge, Everett Pike,	Swampscott.
Paige, George R.,	Amherst.
Peakes, Ralph Ware,	Newtonville.
Pray, Fry Civille,	Natick.
Racicot, Jr., Arthur Alphonse,	Lowell.
Rogers, Stanley Sawyer,	Boston.
Russell, Henry Merwin,	Bridgeport, Conn.
Scott, Edwin Hobart,	Cambridge.
Sleeper, George Warren,	Swampscott.
Strain, Benjamin,	Mt. Carmel, Conn.
Suhlke, Herman Augustus,	Leominster.
Taft, William Otis,	East Pepperell.
Tannatt, Jr., Willard Colburn,	Dorchester.
Tirrell, Charles Almon,	Plainfield.
Wellington, Richard,	Waltham.
Wholley, Michael Francis,	Cohasset.
Wood, Alexander Henry Moore,	Easton.
Total,	34

Sophomore Class.

Alley, Harold Edward,	Newburyport.
Arimoto, Shintaro,	Oharamura, Aidagun, Mimasaka, Japan.
Armstrong, Arthur Huguenin,	Hyde Park.
Barlow, Waldo Darius,	Amherst.
Bartlett, Earle Goodman,	Chicago, Ill.
Brydon, Robert Parker,	Lancaster.
Caruthers, John Thomas,	Columbia, Tenn.

Chace, Wayland Fairbanks,	Middleborough.
Chadwick, Clifton Harland,	Cochituate.
Chapman, Joseph Otis,	Brewster.
Chapman, William Spaulding,	Attleborough.
Clark, Jr., Milford Henry,	Sunderland.
Clementson, Lewis Towland,	Millbury.
Cowles, Edward Russell,	Deerfield.
Curtis, Jesse Gerry,	South Framingham.
Curtis, Walter Leon,	Scituate.
Cutter, Frederick Augustus,	Pelham, N. H.
Dearth, George Augustus,	South Framingham.
Denham, Edwin Tirrell,	Rockland.
Dickinson, Walter Ebenezer,	North Amherst.
Dudley, Fred Samuel,	Montague.
Eastman, Jasper Fay,	Townsend.
Engstrom, Nils,	Lancaster.
Farrar, Allan Dana,	Amherst.
Gould, Harry Wheeler,	Millbury.
Green, Herbert Henry,	Spencer.
Hall, Jr., Walton,	Marshfield.
Hartford, Archie Augustus,	Westford.
Higgins, Arthur William,	Westfield.
Jones, Arthur Merrick,	Ludlow.
King, Clinton,	Easton.
Larned, Joseph Adelbert,	Amherst.
Leighton, Carl,	Lowell.
Leominster, William,	Long Plain.
Lincoln, Ernest Avery,	Fall River.
Livers, Susie Dearing,	Boston.
Parker, Charles Morton,	Newtonville.
Perkins, Edward Cook,*	Springfield.
Peters, Frederick Charles,	Lenox.
Philbrick, Edwin Daniels,	West Somerville.
Pierce, Henry Tyler,	West Millbury.
Pray, Rutledge Peyton,	Natick.
Raitt, John Archibald,	New York, N. Y.
Rice, Charles Arthur Allenham,	Springfield.
Russell, Herbert Osborne,	North Hadley.
Searle, George Whitney,	Westfield.
Shaw, Edward Houghton,	Belmont.
Shaw, Frank Elmer,	Brockton.

* Died June 20, 1904.

Stoddard, Calder Sankey,	Canton.
Summers, John Nicholas,	Brockton.
Thompson, Clifford Briggs,	Halifax.
Walker, James Hervey,	Greenwich Village.
Watkins, Fred Alexander,	Hinsdale.
Watts, Ralph Jerome,	Littleton.
Whitney, John Frank,	Dana.
Wood, Herbert Poland,	Hopedale.
Total,	56

Freshman Class.

Allen, Charles Francis,	Worcester.
Allen, Herbert Carpenter,	East Northfield.
Anderson, Albert John,	North Brookfield.
Anderson, Kenneth French,	Roslindale.
Austin, Frank Lee,	Potsdam, N. Y.
Bailey, Ernest Winfield,	Worcester.
Bangs, Bradley Wheelock,	Amherst.
Barry, Thomas Addis,	Amherst.
Bartlett, Louis Warren,	Amherst.
Bates, Carleton,	Salem.
Bennett, Ernest Victor,	Malden.
Blake, Rodman Ruggles,	East Pepperell.
Blakely, Franklin Chambers,	Medford.
Browne, Marcus Metcalf,	Malden.
Caldwell, John Snow,	Lynn.
Carter, Henry Rufus,	Millbury.
Chapman, Lloyd Warren,	Pepperell.
Chase, Henry Clinton,	Swampscott.
Clark, Orton Loring,	Malden.
Cobb, George Robert,	Amherst.
Coleman, William John,	Natick.
Cox, Leon Clark,	Boston.
Cummings, Winthrop Atherton,	Belchertown.
Cutting, Roy Edward,	Amherst.
Damon, Henry Frank,	Belchertown.
Daniel, John,	Osterville.
Davenport, Stearnes Lothrop,	North Grafton.
Davis, Paul Augustin,	Lowell.
Dolan, Clifford,	Hudson.
Draper, James Edwin,	Worcester.

Eastman, Perley Monroe,	Townsend.
Edmands, Ernest Carl,	Saugus.
Edwards, Frank Laurence,	Somerville.
Farley, Arthur James,	Waltham.
Farrar, Parke Warren,	Springfield.
Flint, Clifton Leroy,	Amesbury.
Fullam, Charles Francis,	North Brookfield.
Gillett, Chester Socrates,	Southwick.
Gillett, Kenneth Edward,	Southwick.
Gold, Frank Lyman,	Amherst.
Goodwin, Chester Linwood,	Brockton.
Gowdey, Carlton Cragg,	St. Michael, Barbados.
Hamburger, Amos Francis,	Hyde Park.
Hayes, Herbert Kendall,	North Granby, Conn.
Hayward, Warren Willis,	Millbury.
Howe, William Llewellyn,	Marlborough.
Hyslop, James Augustus,	Rutherford, N. J.
Ingalls, Dorsey Fisher,	Cheshire.
Jackson, Raymond Hobart,	Amherst.
Jennison, Harry Milliken,	Millbury.
Johnson, Frederick Andrew,	Westford.
Jones, Thomas Henry,	Easton.
Lacouture, George Louis,	Millbury.
Larsen, David,	Bridgeport, Conn.
Liang, Lai-Kwei,	Tientsin, China.
Miller, Danforth Parker,	Worcester.
Negus, Philip Henry,	Fall River.
O'Grady, James Raphael,	Holliston.
Pagliery, Joseph Cecilio,	New York, N. Y.
Parker, John Robert,	Poquonock, Conn.
Potter, John Sherman,	Concord.
Reed, Horace Bigelow,	Worcester.
Regan, William Swift,	Northampton.
Sawyer, William Francis,	Sterling.
Shattuck, Leroy Altus,	Pepperell.
Smith, George Franklin,	Barre.
Thurston, Frank Eugene,	Worcester.
Turner, Olive May,	Amherst.
Turner, William Franklin,	Reading.
Verbeck, Roland Hale,	Malden.
Warner, Theoren Levi,	Sunderland.
Waugh, Thomas Francis,	Worcester.
Wellington, Joseph Worcester,	Waltham.

Wheeldon, Albert James,	Worcester.
Wheeler, Hermon Temple,	Lincoln.
White, Herbert Linwood,	Maynard.
Whiting, Albert Lemuel,	Stoughton.
Whitmarsh, Raymond Dean,	Taunton.
Wright, Samuel Judd,	South Sudbury.
Total,	79

Short Winter Courses.

Abbott, Chester Denning,	Andover.
Austin, Frank Lee,	Potsdam, N. Y.
Blair, Alfred Wingate,	Roxbury.
Browning, Homer Franklin,	Northfield.
Dorr, Herbert Andrews,	Richmond.
Dunbar, Frank Andrews,	Richmond.
Eldridge, Alvah Gorham,	Amherst.
Farwell, Fred Sherman,	West Fitchburg.
Gaskell, Edward Thompson,	Amherst.
Kendrick, Harry Newell,	East Charlemont.
Kilbourn, Farley Eugene,	Ashburnham.
Knox, Harry Cobb,	Roxbury.
Mead, Albert William,	Hartford, Vt.
Millard, Walter Burton,	Egremont.
Newcomb, Walter Lemuel,	Brattleboro, Vt.
Packard, Ransom Clayton,	Brockton.
Perry, Arthur Asa,	South Pomfret, Vt.
Phillips, Homer Grant,	Hadley.
Pick, Fred Mortimer,	Southborough.
Potter, Lincoln,	Worcester.
Runkle, Gordon,	Waltham.
Seely, Will Campbell,	Hamburg, N. J.
Shaw, Chester Linus,	Brockton.
Smith, George Clarence,	East Haddam, Conn.
Smith, Raymond Burr,	Chicago, Ill.
Stearns, Lynn Lawrence,	Hyde Park, Vt.
Thayer, Charles Hiram,	Hadley.
Trufant, Willard Evander,	Abington.
Twichell, Henry Sessions,	Brookfield.
Wilder, Frank Everett,	Petersham.
Wilmarth, Theoph. Williams,	Sunapee, N. H.
Total,	31

Course in Bee Culture.

Elwell, Maria Huntington,	Brooklyn, N. Y.
French, Jr., Thomas,	Amherst.
Hunt, Justine,	Newton.
Parker, Charles Morton,	Newtonville.
Phelps, Mrs. William Augustus,	Lee.
Smith, Raymond Burr,	Chicago, Ill.
Total,	6

Graduate Courses.

For Degrees of M.S. and Ph.D.

Back (B.Sc., M. A. C., '04), Ernest Adna,	Florence.
Franklin (B.Sc., M. A. C., '03), Henry James,	Bernardston.
Hodgkiss (B.Sc., M. A. C., '03), Harold Edward,	Wilkinsonville.
Hooker (B.Sc., M. A. C., '99), William Anson,	Amherst.
Kibbey (A.B., Harvard, '04), Richards Carroll,	Marshalltown, Ia.
Osmun (B.Sc., M. A. C., '03), Albert Vincent,	Danbury, Conn.
Staples (B.Sc., M. A. C., '04), Parkman Fisher,	Westborough.
Tottingham (B.Sc., M. A. C., '03), William Edward,	Bernardston.
Tower (B.Sc., M. A. C., '03), Winthrop Vose,	Roxbury.
Whipple (B.Sc., Kansas Agr'l College, '04), Orville Blaine,	Olivet, Kan.
Total,	10

Special Students.

Ferguson, Mary Effie Van Everen,	Central Valley, N. Y.
French, Vida Rachel,	Amherst.
Locke, Ada Elsie,	Somerville.
Magoun, Alice Neal,	Bath, Me.

Redding, Charlotte Wilmarth,	Amherst.	
Spaulding, Olive Mary,	Mapleton, Conn.	
Thayer, Lucy Clarke,	Hadley.	
Total,		7

Summary.

Graduate course: —		
For degrees of M.S. and Ph.D.,	10	
Four-years course: —		
Graduates of 1904,	20	
Senior class,	33	
Junior class,	34	
Sophomore class,	56	
Freshman class,	79	
Two-years course: —		
Graduate,	1	
Winter courses,	31	
Bee course,	6	
Special students,	7	
Total,	——	277
Entered twice,		6
Total,		271

OBJECT.

The leading object of the Massachusetts Agricultural College is "to teach such branches of learning as are related to agriculture and the mechanic arts, . . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." That this result may be secured by those for whom it is intended, the college invites the co-operation and patronage of all who are interested in the advanced education of the industrial classes in the Commonwealth.

The instruction here given is both theoretical and practical. The principles of agriculture are illustrated on the extended acres of the farm belonging to the college estate. Nature's work in botany and in horticulture is revealed to the eye of the student in the plant house and in the orchards accessible to all, while the mysteries of insect life, the diseases and the cure of domestic

animals, the analysis of matter in its various forms, and the study of the earth itself, "the mother of us all," may engage the attention of the student during the years of his college course.

GRADUATE COURSES.

In response to the increasing demand for advanced work in various directions, the college has arranged for courses of study leading to the degrees of Master of Science and Doctor of Philosophy.

Honorary degrees are not conferred.

Applicants are not eligible to the degree of Master of Science or Doctor of Philosophy until they have received the degree of Bachelor of Science or its equivalent.

The fee for the degree of Master of Science is ten dollars and for the degree of Doctor of Philosophy twenty-five dollars, to be paid to the treasurer of the college before the degree is conferred.

Courses for the Degree of Master of Science.

A course of study is offered in each of the following subjects: mathematics and physics, chemistry, agriculture, botany, horticulture, entomology, veterinary medicine. Upon the satisfactory completion of any two of these, the applicant receives the degree of Master of Science.

Candidates for the degree of Master of Science must devote not less than one year and a half after graduation to the prosecution of two studies for the degree, one year of which must be in residence at the Massachusetts Agricultural College.

Courses for the Degree of Doctor of Philosophy.

The establishment of courses leading to this degree is the result of many calls for advanced study along certain economic lines neglected in most American universities, and is given only by those departments especially equipped for this grade of study, to graduates of this college or other colleges of good standing. The work required for the degree is intended to be so advanced in its character as to necessitate the greatest industry to complete it, with the belief that such severe requirements will result in the greatest credit to those who are successful. Four courses of study only are therefore open, viz., botany, chemistry, entomology and horticulture as major subjects, though a minor in zoölogy is also available.

At least three years are necessary to complete the work required; twenty hours per week to be devoted to the major subject, while from twelve to sixteen hours per week are required for each of the two minor subjects during one and a half years.

The work in the major and minors will necessarily differ with the previous training and needs of different students, but a general outline of the major in each subject is as follows: —

Botany. — Vegetable physiology, vegetable pathology, mycology, œcology, taxonomy, phylogeny, the history of botany, and the history and theory of evolution. The above subdivisions of botany will be, to a greater or less extent, pursued as necessitated by the previous training of the student and nature of the original problem undertaken. In this course it is also recommended that the student take, in addition to this prescribed minor work, a brief course in the history of philosophy and psychology, which at present will have to be provided elsewhere. Extensive reading of botanical literature, of both a general and specific nature, will be required in certain subjects, and occasional lectures will be given. A botanical conference is held monthly, wherein various new problems touching upon botanical science are considered by graduate students and those of the senior class electing botany. A thesis dealing with some economic problem in plant physiology or pathology, or both, and containing a distinct contribution to knowledge, will also be required.

Chemistry. — Advanced work in the following subjects: inorganic analysis, qualitative, of the rarer elements, and quantitative; crystallography; physical chemistry; descriptive and determinative mineralogy; chemical geology; soil formation; soil physics and chemistry; gas analysis; synthetic inorganic work; chemical theory and history; general organic chemistry; special topics in organic chemistry; elementary quantitative organic analysis; proximate qualitative and quantitative organic analysis, including determination of organic radicles; organic synthesis of aliphatic and aromatic compounds; problems in chemical manufacture; recent chemistry of plant nutrition; animal physiological and pathological chemistry, including foods, standards for feeding of all kinds, and, among secretions, milk and milk industries; and, among excretions, urine and urinalysis; toxicology; insecticides and fungicides; frequent examinations on current chemical literature.

Early in the course original work on some chemical subject pertaining to agriculture must be begun. The history and results of

this work must be submitted before graduation, in the form of a thesis containing a distinct contribution to knowledge.

Entomology. — General morphology of insects: embryology; life history and transformations; histology; phylogeny and relation to other arthropods; hermaphroditism; hybrids; parthenogenesis; pædogenesis; heterogamy; chemistry of colors in insects; luminosity; deformities of insects; variation; duration of life.

Œcology: dimorphism; polymorphism; warning coloration; mimicry; insect architecture; fertilization of plants by insects; instincts of insects; insect products of value to man; geographical distribution in the different faunal regions; methods of distribution; insect migrations; geological history of insects, insects as disseminators of disease; enemies of insects, vegetable and animal, including parasitism.

Economic entomology: general principles; insecticides; apparatus; special cases; photography of insects and their work; methods of drawing for illustrations; field work on insects, and study of life histories; insect legislation.

Systematic entomology: history of entomology, including classifications and the principles of classification; laws governing nomenclature; literature, — how to find and use it; indexing literature; number of insects in collections and existence (estimated); lives of prominent entomologists; methods of collecting, preparing, preserving and shipping insects; important collections of insects.

Journal club: assignments of the literature on the different groups of insects to different students, who report at monthly meetings summaries of all articles of value which have appeared during the month.

Required readings of the best articles on the various topics named above, and on the different orders of insects. This reading covers from 15,000 to 20,000 pages in English, French and German, and the candidate is examined on this, together with his other work, at the close of his course.

Thesis: a thesis with drawings, which shall consist of the results of original investigations along one or several lines, and which shall constitute a distinct contribution to knowledge, must be completed and accepted before the final examinations are taken.

Horticulture. — The work in horticulture necessarily varies considerably with different candidates, since its most important features are specialization, original investigation, and the development of individual initiative in dealing with new questions. Each candidate must select some special field of horticultural study, and devote

himself continuously to it. He will be required to attend lectures, conferences and seminars dealing with horticulture in its broader aspects. Advanced work will be required in the following subjects: systematic pomology, pomological practice, commercial pomology; systematic, practical and commercial olericulture; greenhouse plants and problems; floriculture; landscape gardening; plant breeding and general evolution; and questions of a physiological nature connected with propagation and pruning.

Other requirements and opportunities are: (1) periodical seminars with special lectures, by prominent men from outside the college; (2) extensive and systematically planned readings; (3) frequent visits to orchards, gardens, greenhouses, estates and libraries outside the college grounds, always with some definite purpose in view; (4) and, finally, the preparation and publication of a thesis setting forth the results of the candidate's major study, which shall be an original and positive contribution to horticultural knowledge.

Zoölogy. — This course is offered as a minor subject for candidates for the degree of Doctor of Philosophy.

General and comparative anatomy, both gross and microscopic; ontogeny and phylogeny; life cycles, metamorphosis and metagenesis; animal associations, colonial, commensal and parasitic, and symbiotic associations of animals and plants; adaptation, adaptive radiation and parallelisms.

Geologic, geographic and bathymetric distribution of animals.

Systematic zoölogy, including palæozoölogy; museum and field technique.

Economic zoölogy.

History and development of zoölogical science.

Weekly seminars and journal club meetings are held, in which all advanced students of zoölogy take an active part.

Collateral reading and a general knowledge of current zoölogical literature are required.

FOUR-YEARS COURSES.

Degree.

Those who complete the four-years course receive the degree of Bachelor of Science, the diploma being signed by the governor of Massachusetts, who is the president of the corporation.

Regular students of the college may also, on application, become members of Boston University, and upon graduation receive its

diploma in addition to that of the college, thereby becoming entitled to all the privileges of its alumni, provided that the candidate, in addition to the college course, shall have mastered in a preparatory school a three-years preparatory course in studies beyond those commonly presented in the grammar schools of Massachusetts.

Admission.

Every candidate for admission must be at least sixteen years of age, and must present a testimonial of good character from the principal of the last school that he attended.

Certificates. — Certificates of schools and academies approved by the faculty of the college are accepted in place of examinations. These certificates must be made out on blanks furnished on application to the registrar, and must be signed by the principal of the school making such application.

A student admitted on certificate may be dropped from college at any time during freshman year when his work is not satisfactory; and the privilege implied in the acceptance of a certificate may be revoked whenever, in the judgment of the faculty, it is not properly exercised.

Examinations. — Candidates for admission to the freshman class will be received on certificate, as explained above, or on examination in the following subjects: algebra (through quadratics), plane geometry, English, general history, civil government (Mowry's "Studies in Civil Government"), physiology (Martin's "The Human Body," briefer course), physical geography (Guyot's "Physical Geography," or its equivalent).

This examination may be oral or written; the standard required for admission is 65 per cent. in each subject. Knowledge of the principles of arithmetic is presupposed, although an examination in this subject is not required. Teachers are urged to give their pupils such drill in algebra and geometry as shall secure accuracy and readiness in the application of principles to practical examples.

A candidate will not be accepted in English whose work is notably deficient in point of spelling, punctuation, idiom or division into paragraphs. The candidate will be required to present evidence of a general knowledge of the subject matter of the books named below, and to answer simple questions on the lives of their authors. The form of examination will usually be the writing of a paragraph or two on each of several topics to be chosen by the candidate from a considerable number — perhaps ten or fifteen — set before him in the examination paper. The treatment of these

topics is designed to test the candidate's power of clear and accurate expression, and will imply only a general knowledge of the substance of the books. The books set for the examination in 1905 and 1906 are: Shakespeare's "The Merchant of Venice;" Goldsmith's "The Vicar of Wakefield;" Scott's "Ivanhoe;" Tennyson's "The Princess;" Lowell's "The Vision of Sir Launfal;" George Eliot's "Silas Marner."

Examinations in one or more of the required subjects may be taken a year before the candidate expects to enter college, and credit for successful examination in any subject will stand for two years after the examination.

Candidates for classes more advanced than the freshman class will be examined in the studies gone over by the class to which they desire admission.

The examinations for admission in 1905 will be held at the Botanic Museum of the Agricultural College in Amherst on Thursday and Friday, June 22 and 23, and on Tuesday and Wednesday, September 19 and 20, as follows: —

First Day.	*Second Day.*
8.30 A.M. — Registration.	9 A.M. — Civil government.
9 A.M. — English.	10 A.M. — Algebra.
11 A.M. — General history.	2 P.M. — Physiology.
2 P.M. — Geometry.	3 P.M. — Physical geography.

Entrance examinations in June will be held on the same days and in the same order as in Amherst: at Jacob Sleeper Hall, Boston University, 12 Somerset Street, Boston; at Horticultural Hall, Worcester; and at Pittsfield, but candidates may be examined and admitted at the convenience of the examiners, at other times in the year, but not during the summer vacation.

ENTRANCE EXAMINATION PAPERS USED IN 1904.

The standard required is 65 per cent. on each paper.

Algebra.

1. Factor $\frac{8}{x^3} - 27y^6$.

   Factor $a^2x^3 - \frac{8a^2}{y^3} - x^3 + \frac{8}{y^3}$.

2. Simplify $\frac{1-a^2}{(1+ax)^2-(a+x)^2} \div \frac{1}{2}\left\{\frac{1}{1-x}+\frac{1}{1+x}\right\}$.

3. $\frac{7+x}{3}=\frac{9+y}{5}=\frac{11+x+y}{7}$. Solve for x and y.

4. $\left\{(x)\left(\sqrt[n]{x^{-\frac{1}{n}}}\right)\right\}^{\frac{n^2}{1-n}}$. Express with positive exponents, and reduce to lowest terms.

5. Find square root of the binomial surd $4-\sqrt{15}$.

6. $\left\{\frac{x+\sqrt{x^2-9}}{x-\sqrt{x^2-9}}\right\}^{\frac{1}{2}}=x-2$. Solve for x.

7. $\left\{\begin{array}{l}\frac{1}{x^2}+\frac{1}{y^2}=65\\ \frac{1}{x}-\frac{1}{y}=11\end{array}\right\}$. Solve for x and y.

8. $\left\{\begin{array}{l}xy+xy^2=12\\ x+xy^3=18\end{array}\right\}$. Solve for x and y.

Geometry.

1. Prove: in any triangle, the product of any two sides is equal to the product of the segments of the third side formed by the bisector of the opposite angle, plus the square of the bisector.

2. The diameters of two concentric circles are 14 and 50 units, respectively; find the length of the chord of the greater circle which is tangent to the smaller.

3. Prove: two rectangles having equal altitudes are to each other as their bases. Prove case of incommensurable bases only.

4. Prove: two similar triangles are to each other as the squares of homologous sides.

5. The side of an equilateral triangle is 6; find the areas of its inscribed and circumscribed circles.

Physical Geography.

1. Describe the general arrangement of the mountain ranges in North America. How have they influenced the form of the continent? What two agencies have caused its irregularity of outline? Give examples illustrating each.

2. What do you mean by youth, maturity and old age on the part (*a*) of a river; (*b*) of a mountain range; (*c*) of a sea coast? Give the characteristics of each, with examples, preferably such as you have actually seen.

3. Locate and describe the prairies and the great plains, and tell for what industries each is best fitted. Describe also the great desert of the south-west, with its type of vegetation. By what means, if at all, can this desert be made to support mankind?

4. Distinguish between climate and weather. What factors influence the climate of a place? Compare that of Marseilles with that of Portland, Me., and in the same way the climate of London with that of Labrador.

5. Describe a glacier, its origin, moraines and glacial erosion. Are any glaciers found within the limits of the United States; if so, where? Describe the Greenland ice sheet, and tell what evidences we have that such a sheet once covered a part of North America. Give its probable cause, limits and direction of flow.

6. What are the various influences, geographical and climatic, which govern the distribution and migrations of animals and of mankind?

Civil Government.

1. Name the four forms through which the government of this country has passed. Explain these four forms. In what year did each end?

2. Write upon any (six) of the following topics. Accuracy of statement and fulness of detail are important in this work.

(*a*) The preamble to the Constitution of the United States.

(*b*) The legislative department of the State of Massachusetts.

(*c*) The legislative department of the United States government.

(*d*) The present way of choosing the President of the United States.

(*e*) The present way of choosing United States Senators.

(*f*) The executive departments of the United States government.

(*g*) The national bank system.

(*h*) The Louisiana purchase and its results.

Physiology.

1. Define an organ, a tissue, a cell. How may the tissues be classified? What do you mean by physiological division of labor? Illustrate.

2. Compare the blood and lymph. Where does the latter come from and where does the surplus lymph go, and what carries it there? What is the value of the lymph to the various tissues and organs?

3. Describe carefully the human arm, naming the different sorts of tissues found therein, the various bones and their joints, the different levers, and finally the uses of the arm, telling how it is adapted to these uses in comparison with the fore limb of a horse or dog.

4. Compare the veins, arteries and capillaries, with reference to their coats, muscular development, valves and elasticity. What is the pulse, and why is there no pulse in the veins? What causes the blood to flow in the veins?

5. What do you mean by digestion, by absorption, by assimilation? Where and by aid of what juices are the following substances digested: fats, starch and proteids? How do the digested substances get to the tissues which need them, and how are they utilized?

6. Give as fully as you can the anatomy and physiology of the ear, — the external ear, the tympanum, eustachian tube, semicircular canals and the cochlea.

General History.

1. Into what three periods may we divide our study of history? Give as closely as you can the limits of each period, with the reasons for your answer.

2. Describe some of the manners and customs of the early Spartans.

3. Give some of the causes, leaders, chief events and results of the Punic wars.

4. With what do we associate these names: Marathon, Lycurgus, Aristotle, Alexander the Great, Attila, Charlemagne, Peter the Great, the Vandals, Châlons, Richelieu?

5. Tell what you can of the crusades, speaking of their causes, objects, leaders and results.

6. During the Dark Ages two great institutions arose, — the papacy and feudalism. Explain them.

7. Give a brief outline of the Norman conquest of England, telling how it came to pass, what the chief battle was, and the effect on the conquered country.

8. The French revolution: its causes and results.

9. What was the English civil war? Explain its causes, and speak of the great leader it developed.

10. Tell about the Louisiana purchase; by whom made, with what results, and of what especial significance just now.

English.

Note. — Penmanship, punctuation and spelling are considered in marking this paper. The time allowed is two hours.

1. Choose two of the following topics, and write clearly and interestingly upon them. Let each essay be about two hundred words in length.

(*a*) The boyhood of Shakespeare.
(*b*) Shakespeare in London.
(*c*) An outline of Goldsmith's life.
(*d*) Goldsmith's rank in English literature.
(*e*) What Scott did for the English novel.
(*f*) Scott's last days.
(*g*) Lowell's life abroad.
(*h*) Lowell's early surroundings.
(*i*) An outline of Tennyson's life.
(*j*) George Eliot's early days.

2. Choose any five from the following list of subjects, and write a paragraph or two on each subject chosen. Give title in each case.

(*a*) The lesson of the caskets in the "Merchant of Venice."
(*b*) Some interesting characters in the "Vicar of Wakefield."
(*c*) The character of Richard Cœur de Lion, as depicted in "Ivanhoe."
(*d*) Early England, as shown in "Ivanhoe."
(*e*) Tell the story of "The Princess."
(*f*) The great lesson in "The Vision of Sir Launfal."
(*g*) The influence of little Eppie on the character of Silas Marner.

COURSES OF INSTRUCTION FOR THE DEGREE OF BACHELOR OF SCIENCE.

Agriculture.

Introductory: relations of federal and State governments to agriculture, four lectures; history of agriculture, tenure of land, rents, holdings, etc., six lectures.

Freshman year, first semester, three hours a week, required. Animal breeding. Shaw's "Breeding Animals," lectures and discussion of principles of breeding. — Assistant Professor Cooley.

Sophomore year, seven weeks, first semester, four exercises a week in class room, required. Breeds of farm live stock: sheep, cattle. Lecture syllabus by Cooley, and Curtis's "Horses, Cattle, Sheep and Swine." — Assistant Professor Cooley.

Sophomore year, nine weeks, first semester, four exercises a week in class room, required. Horses and swine. Lecture syllabus by Cooley, and Curtis's "Horses, Cattle, Sheep and Swine." — Assistant Professor Cooley.

Sophomore year, eight weeks, second semester, three hours a week, required. Dairying. Lectures on dairy farming, milk production, handling and marketing of milk, milk preservation and modification, and products of milk. Text-book, Wing's "Milk and its Products." — Assistant Professor Cooley.

Sophomore year, ten weeks, second semester, required. Soils: formation, classification, composition; physical and chemical characteristics, and their relations to maintenance and increase in productiveness. Brooks's "Agriculture," Vol. I., supplemented by lectures and laboratory work. — Professor Brooks.

Junior year, ten weeks, first semester, elective. Methods of soil improvement, including tillage, drainage and irrigation. Brooks's "Agriculture," Vol. I., supplemented by lectures, laboratory work and practical exercises. — Professor Brooks.

Junior year, four weeks, first semester, elective. Manures: production, composition, properties, adaptation and use. Brooks's "Agriculture," Vol. II., supplemented by lectures and practical exercises. — Professor Brooks.

Junior year, four weeks, first semester, elective. Stock judging. — Assistant Professor Cooley.

Junior year, second semester, elective. Fertilizers, including a critical study of their production, composition, properties, adaptation and use; and green manuring. Brooks's "Agriculture," Vol. II., supplemented by lectures, laboratory work and practical exercises. — Professor Brooks.

Senior year, four weeks, first semester, four hours a week, elective. Silos and ensilage: historical development; the merits and methods of construction of the different kinds of silos; the crops suited for ensilage; ensilage machinery; the methods of filling the silo; and the nature and extent of the changes taking place in ensilage as affecting food value. Lectures, books of reference and practical exercises. — Professor Brooks.

Senior year, seven weeks, first semester, four hours a week, elective. Feeding animals: principles of digestion and animal nutrition, a study of feeding stuffs (coarse and concentrated). The relation of food to product; compounding rations. Armsby's "Cattle Feeding," lectures and discussion. — Assistant Professor Cooley.

Senior year, seven weeks, first semester, four hours a week, elective. Dairying: selection and management of the dairy farm, dairy cattle, chemical and physical properties of milk, etc., cream, butter, cheese and by-products. — Assistant Professor Cooley.

Senior year, first and second semester, two exercises a week, for ten weeks. Dairy practice: use of separators, Babcock tester, butter making, etc. — Specialists.

Senior year, second semester, elective. The crops of the farm and crop rotation; including a study of the origin and agricultural botany of all the leading crops of the farm, — annual forage crops, grasses and legumes, cereals, root crops, vegetables, tobacco and other special commercial crops; the production and use of each; the varieties and methods of improvement; the adaptation to soil; the special manurial requirements and the methods of raising and harvesting are considered. Lectures, reference books and field work. — Professor Brooks.

Senior year, second semester, elective. Agricultural experimentation: objects, methods, sources of error; interpretation of results. Lectures and study of reports, bulletins, etc. — Professor Brooks.

Senior year, second semester, elective. Farm management: selection of the farm, its subdivisions and equipment, buildings, fences, roads, water supply; farm capital, permanent, perishable and floating; the labor of the farm and its management; farm power and farm machinery. Lectures and practical exercises. — Professor Brooks.

Seminar courses, by arrangement, for advanced students.

Special problems requiring experiment or other research investigation will be assigned to students fitted for and desiring such work.

Training and practice in the use of farm implements and machines by arrangement when desired.

Horticulture.

This department endeavors to give the student a working knowledge of horticulture on its practical and on its scientific side. The attempt is made to inculcate a taste and an enthusiasm for horticultural pursuits, in place of distaste and dislike for the drudgery of farm life. On these things success and further progress chiefly depend.

The courses now offered are as follows, though others will be added as occasion requires: —

1. Sophomore class, second semester. The fundamental opera-

tions of horticulture, — propagation, pruning and cultivation, — as related to the physiology of the plant. During the first half of this course Bailey's "Nursery Book" is used as a text. — Mr. GREENE.

2. Junior year, first semester. Pomology: this course covers the three natural divisions of the subject, viz.: (*a*) systematic pomology, or the study of the fruits themselves; (*b*) practical pomology, or the practice of fruit growing; (*c*) commercial pomology, or the principles underlying the marketing of fruits. The course is pursued by means of text-book, lectures, laboratory and field exercises. — Mr. GREENE.

3. Junior year, first semester, four periods weekly. Plant breeding: based on a thorough examination of the laws of heredity and of variation, and of the principal theories of evolution. Lectures, accompanied by practice and direct experiments in crossing and hybridizing plants. — Professor WAUGH.

4. Junior year, second semester, four periods weekly. Market gardening, including vegetables and small fruits; locations, soils, methods of cultivation and marketing. Text-book, Bailey's "Principles of Vegetable Gardening," lectures and field exercises. — Mr. GREENE.

5. Individual problems will be assigned to seniors who elect horticulture. This gives the student an opportunity for specialization in various lines of fruit growing, vegetable culture, greenhouse management, landscape gardening, etc. — Professor WAUGH, Mr. GREENE and Mr. CANNING.

A seminar, made up of all students electing advanced work in horticulture or landscape gardening, meets at regular intervals for the discussion of any matters pertaining to the subject. Successful and noted horticulturists from outside the college are frequently present at these meetings, to speak on the topics with which they are especially identified.

Landscape Gardening.

The college wishes to promote the work in landscape gardening in every way possible. The aim of the courses is to give the general student an understanding of the fundamental principles of design and of good taste as applied to gardening, and to prepare advanced students for the practice of landscape gardening in its various branches.

Although a variety of other work along related lines is available, the courses now definitely offered are as follows: —

1. Junior year, four periods weekly. Materials: this course is designed to give the student an intimate acquaintance with the trees, shrubs and other plants used in landscape gardening. — Professor Waugh and Mr. Canning.

2. Junior year, second semester, four hours a week. Elements of landscape design: the fundamental principles underlying the artistic development of parks, estates, gardens and other areas, together with some of the simpler applications to practical conditions. During the first half of the term Waugh's "Landscape Gardening" will be used as a text. — Professor Waugh.

3. Senior year, first and second semesters, four laboratory periods weekly. Advanced landscape gardening: lectures, conferences, field exercises and extensive practice work with criticism. The student is given definite problems to solve, these problems being arranged in such an order as to develop the subject logically in the student's mind. — Professor Waugh and Mr. Canning.

Chemistry.

This course aims to inculcate accurate observation, logical thinking, systematic and constant industry, together with a comprehensive knowledge of the subject. Instruction is given by text-book, lectures and a large amount of laboratory work under adequate supervision. The laboratory work at first consists of a study of the properties of elementary matter, analysis of simple combinations and their artificial preparation. This is followed by a quantitative analysis of salts, minerals, soils, fertilizers, animal and vegetable products. The advanced instruction takes up the chemistry of various manufacturing industries, especially those of agricultural interest, such as the production of sugar, starch and dairy products; the preparation of animal and plant foods, their digestive assimilation and economic use; the official analysis of fertilizers, fodders and foods; and the analysis of soils, waters, milk, wine and other animal and vegetable products.

The courses are as follows: —

Freshman year, second half of second semester, four hours a week. General chemistry, part 1, principles of chemistry, non-metals. Newth's "Inorganic Chemistry." — Assistant Professor Howard.

Sophomore year, first semester, six hours a week. General chemistry, part 2, metals. — Assistant Professor Howard.

Second semester, five hours a week. Subject continued; dry analysis. — Assistant Professor Howard.

Junior year, first semester, eight hours a week. Qualitative and quantitative analysis; organic chemistry. Four hours a week, special subject. — Professor WELLINGTON.

Second semester, ten hours a week. Organic chemistry. Remsen's "Organic Chemistry." Five hours a week, special subject. — Professor WELLINGTON.

Senior year, elective, first semester, three hours a week. Chemical industries. — Professor GOESSMANN.

Eight hours a week, quantitative analysis and physical chemistry. Reychler-McCrae's "Physical Chemistry." — Professor WELLINGTON and Assistant Professor HOWARD.

Second semester, eight hours a week. Advanced work, with lectures. — Professor WELLINGTON.

GEOLOGY.

1. Mineralogy, junior year, first semester, six weeks, three hours a week. A course of systematic determinative mineralogy, based on Brush's "Manual." This work is carried on in the laboratory, and consists in determining the minerals by a study of lustre, fusibility, hardness, color, streak, specific gravity, etc., and by some of the simpler chemical tests. — Assistant Professor HOWARD.

2. Geology, junior year, second semester, twelve weeks, three hours a week. Structural, dynamical, physiographical and historical, based upon Scott's "Introduction to Geology." The course aims to give a review of the physical condition of the earth; the various dynamic agencies, and the results of their activities; the origin and structure of the rocks; and, finally, the geological history of the globe, and the appearance in time and the development of the principal races of animals and plants. The museum, lantern slides and the classic Connecticut valley afford ample means for illustration. — Professor LULL.

ZOÖLOGY.

1. Anatomy and physiology, freshman year, one-half of the second semester, four hours a week. A text-book, Martin's "The Human Body," advanced course, is used, from which daily recitations are assigned, supplemented by demonstrations from the charts and models and from microscopic and other preparations. The fact that the subject is required for entrance makes it possible in a comparatively brief period to review the main features

of human anatomy, the generally accepted views concerning the physiology of the various organs, and the more essential laws of health; and, aside from the practical value of the last, the knowledge of the human system thus gained aids greatly in the zoölogical work to come. — Professor Lull.

2. Zoölogy, sophomore year, first semester, two periods a week. This is mainly a laboratory course, the aim being to familiarize the student with the structure of a number of typical forms, representative of the chief phyla of the animal kingdom, to train him to more precise habits of observation, and to lay the foundation for a more thorough understanding of laboratory technique. Lectures, amply illustrated by specimens, charts and lantern slides, supplement and render orderly the knowledge gained in the laboratory. — Professor Lull.

3. Zoölogy, elective, junior year, four periods a week. A course in comparative morphology and systematic zoölogy, based upon Parker and Haswell's "Text-book of Zoölogy." Opportunity is given for the careful dissection of each of the typical forms or its equivalent, described in the text, with a further series of animals for comparative study. Special attention is paid to individual and racial development, adaptation, relationship of animals to one another and to plants, geological and geographical distribution of animals, and the economic importance of the different groups, except the insects, both living and extinct. The lectures are illustrated by the very complete museum collection. — Professor Lull.

Political Science.

The purpose of the entire course is to fit the student to understand the economic and political movements of his time, so that he may successfully solve the problems confronting him.

Economics, junior year, first semester, four hours a week. (1) The elements of political economy are taught by means of text-book (this year Henry Rogers Seagen's "Introduction to Economics") and lectures, the aim being to make the student familiar with the generally accepted facts, definitions, principles and laws of the science; and to train him to criticise theories, scrutinize facts and weigh arguments. (2) The industrial history of England and of the United States is studied. Gibbins's "Industrial History of England" is used. (3) The following elective courses are offered: economics of agriculture; banks and banking; problems of the currency; trusts or monopolistic corporations; transportation; socialism. (4) Practical economics. Each member of the class

selects for investigation a question in which he is interested, and devotes two or three months to its solution.

Papers giving the results of research, prepared by members of the class, are read and discussed by the students. Each student is asked to explain and defend from criticism the statements and the conclusions made in the paper he presents. The department has at its disposal a working library and a collection of material for the use of students. — Professor WALKER.

Constitution of the United States, senior year, four hours a week during the last half of the first semester and the whole of the second semester. (1) Political institutions. By use of text-book (Albert Bushnell Hart's "Actual Government") and lectures the student is led to understand what is the government, municipal, State and federal, now existing in the United States. This government is compared and contrasted with the governments of England, France and Germany. Care is taken to familiarize the student with the practical methods of legislation, of nominating conventions, of elections and of administration. Woodrow Wilson's "The State" is used as a book of reference. (2) Constitutional history of the United States, with discussions relating to the origin, nature, scope and purpose of government. Bancroft's "History of the Constitution of the United States" is used as a book of reference. — Professor WALKER.

Lectures on law, second semester, one hour a week. This course treats of laws relating to business, especially to business connected with rural affairs, citizenship, domestic relations, farming contracts, riparian rights, real estate and common forms of conveyance. Practical work is required, such as may fit one to perform the duties of a justice of the peace. — Mr. LYMAN.

ENGLISH.

This department aims to secure: (*a*) ability to give written and oral expression of thought in correct, effective English; (*b*) acquaintance with the masterpieces of American and English literature; (*c*) ability to present, logically and forcibly, oral and written arguments on propositions assigned for debate.

The following courses are offered: under (*a*) rhetoric and oratory; under (*b*) American literature and English literature; under (*c*) argumentation. The elective course in senior year is in language and literature.

1. *Rhetoric.* — This course extends through the two semesters of freshman year and through the second semester of sophomore

year. In the first semester of freshman year work is confined to essay writing and to personal criticism, by the instructor, of the students' compositions. This criticism is offered at stated intervals to each student individually, according to a posted schedule of appointments. At the beginning of the semester necessary information with regard to the preparation of essays is furnished each student. In the second semester of freshman year the study of literary types is undertaken in the form of class room work in prose composition, including exposition, persuasion, narration, description, and in prose diction, including usage and style. Special attention is given to the training of the inventive ability of the student. The text-book used is Baldwin's "College Manual of Rhetoric." In the second semester of sophomore year individual work in essay writing is again taken up, largely based upon the previous work of the class in American literature (see 3, below). Here also personal criticism is offered. — Assistant Professor Babson.

2. *Oratory.* — Individual drill in declamation, first in private and then before the class, is given during the second semester of freshman year. The choice of speakers for the Burnham prizes is based upon this work. In the junior year, during the first semester, at least two orations, upon subjects assigned or chosen, are written, and delivered before the class. Every oration is criticised by the instructor before it is committed to memory by the student. The choice of speakers for the Flint prizes in oratory is based upon this work. — Assistant Professor Babson.

3. *Literature.* — American literature is studied in the first semester of sophomore year, four hours a week. The course comprises, first, the careful study of a text-book (Newcomer's "American Literature"), together with recitations based upon the same; secondly, the taking of notes from lectures, dwelling upon topics not fully treated in the text-book; and, thirdly, the reading outside of the class room of assigned selections from the prose and poetical works of standard American authors. — Assistant Professor Babson.

The history of English literature is studied during the second semester of sophomore year, four hours a week. The work is based upon a text-book, this year Johnson's "History of English and American Literature." The topical method is followed in recitation, and, instead of formal lectures, there are discussions of points requiring a fuller development than the text-book gives. Collateral readings of literature are required. Frequent written

tests are given, in which particular attention is given to (*a*) the definition of words used in the text-book; (*b*) the use of English in the development of the topics unfolded in the text-book or discussed in the class room. — Professor Mills.

4. *Argumentation.* — Four hours a week during the first semester of junior year are given to written and oral argumentation. The course is outlined as follows: (*a*) principles of argumentation as laid down in a text-book or by lecture; (*b*) briefs and brief-making; (*c*) briefs developed into forensics and submitted for personal criticism; (*d*) debates. — Professor Mills.

Senior elective course, two semesters, four hours a week. The work in this course is upon the following subjects: (*a*) English language, its origin, history and development, with particular attention to the study of words as outlined in Anderson's "A Study of English Words;" (*b*) English literature, principally of the eighteenth and nineteenth centuries. — Professor Mills.

Veterinary Science.

The course of instruction in veterinary science has been arranged to meet the demands of the students who, after graduation, purpose following some line of work in practical agriculture. Particular stress is laid upon matters relating to the prevention of disease in animals. In addition, the interests of prospective students of human and comparative medicine have been taken into account in the arrangement of the course of study. The subject is taught by lectures, laboratory exercises, demonstration and clinics.

Senior year, elective, first semester, four hours a week. Veterinary hygiene, comparative (veterinary) anatomy, general pathology. — Professor Paige.

Second semester, four hours a week. Veterinary materia medica and therapeutics; theory and practice of veterinary medicine; general, special and operative surgery; veterinary bacteriology and parasitology; medical and surgical clinics. — Professor Paige.

The instruction in bacteriology is given by means of lectures, recitations and laboratory exercises. The object of this course of study is to acquaint the student with the various organisms found in air, water, soil, milk and the body, and their relation to such processes as decomposition, fermentation, digestion and production of disease. The toxic substances resulting from the growth of organisms are considered, as well as the antitoxines used to counteract their action.

Senior year, first half of the first semester, four laboratory exercises, of two hours each a week, required. — Professor Paige.

Botany.

The object of the course in botany is to teach those topics pertaining to the science which have a bearing upon economic and scientific agriculture. The undergraduate work extends through six semesters. The first two semesters are required. An outline of the course follows: —

Freshman year, first semester, five hours a week. Laboratory work and lectures; histology and physiology of the higher plants. This includes a study of the minute structure of the plant organism, such as stems, roots, leaves, seeds, etc., and of their functions and chemical and physical properties. This course extends into the next semester. — Mr. Franklin.

Freshman year, second semester, three hours a week. Laboratory work, lectures and text-book; outlines of classification and morphology of the higher plants. This course follows the preceding one, and commences about the first of March. It is devoted to a study of the relationship of plants, their gross structure, together with extensive individual practice in flower analysis. An herbarium of two hundred species of plants is required. — Mr. Franklin.

Junior year, first semester, five hours a week. Two laboratory exercises and one lecture period a week. Cryptogamic botany. This includes a study of the lower forms of plant life, and is necessary for a comprehension of the following courses. — Mr. Franklin.

Junior year, second semester, five hours a week. Two laboratory exercises and one lecture period a week. Elements of vegetable pathology and physiology. This course includes a study of the common fungous diseases of crops, and consideration of the method of prevention and control of the same. The plant's function as related to susceptibility to disease is also taken up. All of the junior botany is included in four of the junior elective courses. — Professor Stone.

Senior year, elective, both semesters. Three laboratory exercises and one lecture period a week. (*a*) Plant physiology; (*b*) plant pathology. Either course is optional. This course is adapted to students who desire a more detailed knowledge of plant diseases and plant physiology. Extensive use is made of the valuable and constantly increasing experiment station literature. — Professor Stone.

Mathematics, Physics and Engineering.

This department has charge of the instruction in mathematics, physics, civil engineering and drawing. The aim is to secure thorough work in the fundamental principles, and train the mind in clear and logical thinking. The application of the subjects to practical problems is given special attention. The work of the department extends over the four years, as outlined below.

Mathematics.

Freshman year, first semester, five hours a week. Higher algebra, including ratio and proportion, progressive binomial theorem, series undetermined coefficients, logarithms, continued fractions, permutations. Wells' "College Algebra." — Professor Hasbrouck.

Second semester, two hours a week. Solid geometry. Wells' "Solid Geometry." — Professor Hasbrouck.

Plane trigonometry, two hours a week. Phillips and Strong's "Elements of Trigonometry." — Professor Ostrander.

Junior year, for mathematical and chemical students, first semester, four hours a week. Analytic geometry of the line, circle, conic sections and higher plane curves. Nichols' "Analytic Geometry." — Professor Ostrander.

Second semester, four hours a week. Differential and integral calculus. Osborne's "Calculus." — Professor Hasbrouck.

Physics.

Sophomore year, first semester, four hours a week. Elementary mechanics of solids, liquids and gases, heat and sound. Dana's "Elementary Mechanics," Carhart's "University Physics." — Professor Hasbrouck.

Second semester, four hours a week. Electricity, magnetism and light. Carhart's "University Physics." — Professor Hasbrouck.

Senior year, elective for those students who have taken junior mathematics; first semester, four hours a week. Analytic mechanics. Peck's "Analytic Mechanics." — Professor Hasbrouck.

Second semester, four hours a week. Laboratory work. — Professor Hasbrouck.

Civil Engineering and Surveying.

Sophomore year, second semester, two exercises of two hours a week. Plain surveying with field work, including the use of the usual surveying instruments. Barton's "Surveying." — Professor OSTRANDER.

Instruction in civil engineering will be given in two distinct courses of one year each, the courses alternating. They will be open to students of the junior and senior classes as indicated below. The course for 1904–05 will be for students in mathematics only. First semester, three hours' recitation and two hours' draughting a week. Stresses in roofs, bridges and graphic statics. Merriman and Jacoby's "Roofs and Bridges," Parts I. and II.

Second semester, four hours a week. Hydraulics and sanitary engineering. Merriman's "Hydraulics and Lectures." — Professor OSTRANDER.

The course of 1905–06 will be required of juniors and seniors taking the courses in mathematics and landscape gardening.

First semester, four hours a week. Strength of materials, foundations and masonry construction. Text-book and lectures. — Professor OSTRANDER.

Second semester, three hours' recitation or lectures and two hours' field work or draughting a week. Topographic and higher surveying, highway construction, the measurement of earth work, pavements and railroad construction. Text-book and lectures. — Professor OSTRANDER.

Drawing.

Junior year, first semester, two two-hour sessions a week for students in mathematics and landscape gardening; free-hand drawing.

Second semester, two two-hour sessions a week. Mechanical and topographic drawing.

ENTOMOLOGY.

The importance of a knowledge of insects in every department of life is recognized by placing an introductory course in this subject as a required study in the junior elective courses: (1) agriculture, (2) horticulture, (3) biology, (4) landscape gardening. For those who desire a further knowledge of it, because of its importance to their future occupations, a senior elective is offered, so shaped as to be of especial value for those who expect to take

up agriculture, horticulture, landscape gardening, forestry or science teaching as life occupations.

Junior year, second semester, four exercises a week, of two hours each. Lectures, laboratory and field work; general consideration of insect structure and life histories; systematic study of the groups of insects, with particular reference to those of economic importance; methods for preventing or checking their ravages; insecticides and apparatus for their use; the collecting, mounting and naming of insects, and examination of the work of insects in the field and laboratory. — Professor H. T. Fernald.

Senior year, elective, first and second semesters, four laboratory exercises of two hours each a week. Lectures, laboratory and field work; advanced morphology of insects; economic entomology; training in the determination of insects; use of literature on entomology; study of life histories; value and application of insecticides; thesis on insects most closely related to future occupation of the student. — Professors C. H. Fernald and H. T. Fernald.

Modern Languages.

French. — Course I.: requires, for the two semesters of the freshman year, four hours a week first semester, four hours a week second semester. The aim of this course is to enable the student to read modern French fluently, especially that found in scientific journals and treatises. The first ten weeks are devoted to gaining a thorough mastery of the accent, and such principles of grammar and syntax as are covered by the first half of Whitney's "French Grammar." Great stress is laid upon the acquisition of a correct accent, a good vocabulary, and a thorough comprehension of the main idiomatic difficulties of the language. This course is further strengthened by constant drill in pronunciation, exercises and composition. — Mr. Herrick.

Course II.: elective for both semesters of the senior year, four hours a week. The aim of this course is to equip the student with a general knowledge of classical literature, and a working knowledge of the language as it is spoken and written in the French capital to-day. Drill is furnished in composition, principles of syntax and sight translation. Students electing Course II. must have a good record in Course I., or must pass a satisfactory examination therein. — Mr. Herrick.

Spanish. — Given this year as a special elective for both semesters, four hours a week. The special aim is to enable students planning future fields of work in Spanish-speaking countries to

acquire sufficient speaking and writing knowledge of the Castilian dialect to enable them to start to best advantage. Especial attention is given to conversation, the method employed being that found in Marion and Garennes' "Introdución á la Lengua Castellana." Grammar rudiments, accent and idiomatic difficulties are thoroughly studied; the acquisition of a good working vocabulary is insisted upon, and the course is further strengthened by practice in writing from dictation, constant drill in pronunciation, exercises and composition, and the reading of books characteristic of modern Spanish life and customs. — Mr. Herrick.

German. — Course I.: required for both semesters of sophomore year, four hours a week first semester, three hours a week second semester. An understanding of the rudiments of grammar, facility in translation and an ability to pronounce the language and to understand simple spoken German are the main objects in view. — Assistant Professor Babson.

Course II.: elective for both semesters of senior year, four hours a week. Special attention is given to the reading of German, particularly to German of a scientific nature. Work is also required in prose composition throughout the year. Accuracy in pronunciation, the ability to understand German as spoken in the class room, and to converse within reasonable limits, are also features of this course. Students electing Course II. must have a good record in Course I., or must pass a satisfactory examination therein. — Assistant Professor Babson.

Military Science.

In compliance with the provisions of an act of Congress of July 2, 1862, military instruction under a regular army officer, detailed for this purpose, is required of all able-bodied male students. Men are excused from attendance upon the exercises of this department only on a surgeon's certificate, given by Dr. Charles F. Branch, the college physician.

The object of such instruction is clearly to disseminate the elements of military knowledge throughout the country, that, in case of sudden emergency, a sufficient number of well-trained, educated men may be found to command and properly to instruct volunteer troops. Military drill also has the object in view of giving the student physical exercise, teaching respect and obedience to those in authority without detracting from pride of manhood, and developing a military bearing and courtesy becoming in a citizen as in a soldier.

In order to further stimulate the study of military science in colleges, the War Department issued General Orders, No. 6, dated Washington, D. C., Aug. 24, 1903, as follows: —

The reports of the regular inspections of the colleges and schools to which officers of the army are detailed, in pursuance of law, as principals or instructors, will annually hereafter be submitted to the general staff for its critical examination, and the chief of staff will report to the Secretary of War, from the institutions which have maintained a high standard, the six institutions whose students have exhibited the greatest interest, application and proficiency in military training and knowledge. The President authorizes the announcement that an appointment as second lieutenant in the regular army will be awarded to an honor graduate of each one of the six institutions, provided sufficient vacancies exist after caring for the graduates of the military academy at West Point and the successful competitors in the annual examination of enlisted men. . . .

By order of the Acting Secretary of War,

S. B. M. Young,

Lieutenant-General, Chief of Staff.

Course I.: out of doors, an exercise of one hour, three times a week, Mondays, Tuesdays and Thursdays; infantry drill by squad, company, and battalion; guard mounting, dress parade, inspection and review; artillery drill by detachment; target practice. A guard is mounted five times in each week, and the guard maintained under practical instruction for one hour in each exercise.

All drills are in the drill hall during the winter months and inclement weather.

Students assigned to the college band are given instruction and practice in band music and band evolutions, in place of drills and recitations.

Course II.: theoretical instruction for freshmen, one hour a week for both semesters, comprises recitations in infantry drill regulations; "United States Service Manual."

Course III.: theoretical instruction for seniors for both semesters, one hour a week, embraces drill and army regulations; duties of sentinels and guard duty, elements of military science, preparation of necessary reports and returns pertaining to a company of infantry, and a thesis on some military subject; Wagner's "Elements of Military Science." — Major Anderson.

Synopsis of the Courses of Instruction.

[The figures indicate the number of exercises a week; light-faced type, recitation periods of one hour each; heavy-faced type, laboratory periods of two hours each.]

Freshman Year.

First Semester.

Language,	English,	3	
	French,	4	
Mathematics,	Algebra,	5	
Science,	Agriculture,	4	
	Botany, 2+1,	3	
Military,	Tactics,	1	
History,		2	
		—	22

Second Semester.

Language,	English,	4	
	French,	4	
Mathematics,	Geometry and trigonometry,	4	
Science,	Anatomy and physiology, half semester, } Chemistry, half semester,	4	
	Botany, 1+1,	2	
History,		2	
		—	20

Sophomore Year.

First Semester.

Language,	English,	4	
	German,	4	
Physics,		4	
Science,	Agriculture,	4	
	Chemistry,	**3**	
	Zoölogy, 1+1,	2	
		—	21

Second Semester.

Language,	English,	4	
	German,	3	
Physics,		4	
Surveying,		**2**	
Science,	Agriculture, 2+1,	3	
	Chemistry,	**2½**	
	Horticulture,	3	
		—	21½

JUNIOR YEAR.

First Semester.

Course in agriculture,	Agriculture, 3+1,	4	
	Botany, 2+1,	3	
	Chemistry,	3	
	Geology,	3	
	Horticulture,	3	
	English,	4	
		—	20
Course in horticulture,	Horticulture,	4	
	Horticulture, 1+3,	4	
	Botany, 2+1,	3	
	Chemistry,	3	
	Geology,	3	
	English,	4	
		—	21
Course in biology,	Zoölogy, 3+1,	4	
	Botany, 2+1,	3	
	Chemistry,	3	
	Geology,	3	
	Horticulture,	3	
	English,	4	
		—	20
Course in chemistry,	Chemistry,	4	
	Agriculture, 3+1,	4	
	Mathematics,	4	
	Geology,	3	
	English,	4	
	Special subject,	2	
		—	21
Course in mathematics,	Analytical geometry,	4	
	Engineering, 1+3,	4	
	Free-hand drawing,	2	
	Landscape gardening,	4	
	Geology,	3	
	English,	4	
		—	21
Course in landscape gardening,	Landscape gardening,	4	
	Agriculture, 2+1,	3	
	Botany, 2+1,	3	
	Free-hand drawing,	2	
	Horticulture,	3	
	Geology,	3	
	English,	4	
		—	22

Second Semester.

Course in agriculture,	Agriculture, 2+1,	3	
	Botany, 2+1,	3	
	Chemistry,	4	
	Horticulture,	2	
	Entomology,	4	
	Economics,	4	
		—	20
Course in horticulture,	Horticulture,	4	
	Botany, 2+1,	3	
	Chemistry,	4	
	Landscape gardening,	2	
	Entomology,	4	
	Economics,	4	
		—	21
Course in biology,	Entomology,	4	
	Zoölogy,	3	
	Botany, 2+1,	3	
	Chemistry,	4	
	Horticulture,	2	
	Economics,	4	
		—	20
Course in chemistry,	Chemistry,	5	
	Agriculture, 2+1,	3	
	Mathematics,	4	
	Economics,	4	
	Special subject,	5	
		—	21
Course in mathematics,	Engineering,	5	
	Mathematics,	4	
	Mechanical drawing,	2	
	Landscape gardening,	4	
	Economics,	4	
		—	19
Course in landscape gardening,	Landscape gardening,	4	
	Botany, 2+1,	3	
	Mechanical drawing,	2	
	Engineering,	5	
	Entomology,	4	
	Economics,	4	
		—	22

Senior Year.

First Semester.

The following subjects are required in all courses: —

Bacteriology, half semester, 4,		
Constitution of the United States, half semester, 4,	4	
Military science,	1	
	—	5

Second Semester.

Constitution of the United States,	4	
Military science,	1	
	—	5

From the following the student must elect three courses, closely correlated with his junior year course; only one course in language may be elected: —

Agriculture,	4	Physics,	4
Horticulture, 3+1,	4	Engineering,	4
Veterinary,	4	English,	4
Botany, 3+1,	4	French,	4
Landscape gardening,	4	German,	4
Entomology, 3+1	4	Spanish,	4
Chemistry, 3+1,	4	Latin,	4

COURSES OF INSTRUCTION FOR SPECIAL STUDENTS.

A Two-Years Course for Women.

Women are received who wish to pursue the studies named below. No admission examinations are required. There is no charge for tuition. Board may be obtained in the dining hall, and also rooms, so far as the accommodations will permit.

First year, first semester: soils, fertilizers and cultivation, four hours a week; elementary botany, five hours; French, four hours; free-hand drawing, four hours.

Second semester: propagation and pruning (horticulture, one hour), three hours; botany, — morphology, plant analysis, five hours; chemistry, descriptive, five hours; vegetable gardening, four hours; French, four hours.

Second year, first semester: pomology, three hours a week; greenhouse construction and management, three hours; botany, — structure and physiology of plants, five hours; zoölogy, two hours; chemistry, five hours; German, four hours.

Second semester: landscape gardening, three hours a week; floriculture, four hours; vegetable pathology, five hours; entomology, three hours; chemistry, five hours; German, three hours.

Short Courses.

These courses are open to persons of both sexes. Applicants must be at least sixteen years of age, and must furnish papers certifying good moral character. No entrance examination is required. Tuition is free to citizens of the United States. The same privileges in regard to room and board obtain as with other students. Attendance upon chapel is required. The usual fees are charged for apparatus and material used in laboratories. Attendance upon military drill is not expected.

I. Dairy Farming.	Hours per Week.
Soils, tillage and methods of soil improvement; manures and fertilizers and their use; crops and rotations,	4
Breeds and breeding of dairy stock; judging to scale of points,	2
Fodders and feeding farm live stock,	1
Stable construction and sanitation,	1
Common diseases of stock; prevention and treatment,	1
Dairy products: their general characteristics; testing,	2
Chemical composition of milk and of special milk products,	1
Botany,	2
Horticulture,	3
Entomology,	3
Dairy practice, including testing, use of separators, butter making, preparation of certified and modified milk, and pasteurization,	4
Practice in horticulture,	1

Begins first Wednesday in January, and continues ten weeks.

II. Horticulture.	Hours per Week.
Soils, tillage, manures, etc.,	4
Plant propagation and pruning,	3
General fruit growing,	3
Market gardening,	3
Botany,	4
Entomology,	3
Practice work in seed testing, seeding, grafting, budding, transplanting, judging fruit, etc.	

Begins first Wednesday in January, and continues ten weeks. This course will not be given unless at least eight men register for it.

III. Short Course in Bee Culture.	Total Hours.
The structure of bees, with special reference to their work (Prof. H. T. Fernald),	3
Flowers and fruits in their relations to bees (Professor Stone),	10
Honey crops, and how to grow them (Professor Brooks),	5
Bees and bee keepers' supplies (Professor Paige),	10
Work in the apiary, under direction of an expert,	20
Instruction by specialists,	4

This course begins the fourth Wednesday in May, and continues two weeks, but will not be given unless applied for by at least six students.

EQUIPMENT OF THE SEVERAL DEPARTMENTS.

Agriculture.

The part of the college estate assigned to the department of agriculture contains one hundred and sixty acres of improved land, forty acres of pasture and sixteen acres of woodland. The latest inventions in improved agricultural tools and machinery are in practical use. The large and commodious barn and stables are stocked with the best breeds of horses, cattle, sheep and swine. Attached to the barn is a dairy building equipped with the latest machinery, driven by an electric motor. The laboratory is provided with the latest forms of apparatus for mechanical analysis of soils and determination of their physical characteristics. Provision has been made in the laboratory for the study of seeds and crops and for germination trials. Power has been introduced into the laboratory, so that farm machinery may be operated for purposes of demonstration. The department has also a line of instruments for use in drainage and irrigation practicums. The museum contains a collection of implements, seeds, plants and models of animals, all of which are designed to illustrate the evolution and the theory and practice of agriculture. Three large lecture rooms, one in south college and two in the dairy building, and five rooms for laboratory and dairy purposes, have been assigned to this department.

Horticulture.

For illustration of the science and the practice of horticulture the department possesses about one hundred acres devoted to orchards planted with all the leading old and all new varieties of apples,

pears, peaches, plums, Japanese and American cherries, quinces, chestnuts, hickory nuts and walnuts; vineyards containing nearly two hundred named varieties of grapes, for sale, beside several hundred seedlings, and about an acre devoted to a commercial crop of a few market varieties; nurseries containing all kinds of fruit and ornamental trees, shrubs and plants, in all stages of growth, from the seed and cuttings to those ready for planting in the orchard or field; small fruit plantations containing valuable varieties, and showing the modern methods of training, pruning and cultivation; extensive greenhouses that contain not only valuable collections of specimen plants, representing types of the flora of the world, but also the most valuable economic plants, such as the orange, banana, lemon, guava, pomegranate, sago palm, arrowroot, tapioca, ginger, pepper, tea, coffee, camphor, India rubber, Manila hemp, banyan tree, etc. All the common greenhouse and outdoor decorative plants are found, and small quantities of roses, carnations, chrysanthemums and other commercial flowering plants are grown, to illustrate the business of horticulture. All vegetable crops, now so largely grown under glass, are grown in limited quantities for purposes of instruction and for market.

For illustration in the work of landscape gardening, the grounds about the greenhouses, as well as that part of the grounds known as the Clark Park, are planted with a very large and complete collection of ornamental trees, shrubs and plants.

For forestry there are two large groves of trees of varying ages, from those of almost primeval growth to the youngest seedlings, besides several plantations of younger growth either natural or planted; and in the Botanical Museum there is a very complete collection of woods of Massachusetts.

All kinds of pumps and other appliances for distributing insecticides and fungicides, as well as various modern tools and implements, are in constant use.

A small cold-storage room makes possible the keeping of the products beyond their natural season, and illustrates one of the most important adjuncts to the business of modern horticulture.

Chemistry.

This department has fourteen rooms, well adapted to their special uses. They are supplied with a large assortment of apparatus and chemical materials. The lecture room on the second floor has a seating capacity for seventy students. Immediately adjoining it are four smaller rooms, used for storing apparatus

and preparing materials for the lecture table. The laboratory for beginners is a large room on the first floor, furnished with forty working tables. Each table is provided with reagents and apparatus for independent work. A well-filled laboratory for advanced work is also provided on the first floor. A weighing room has six balances, and improved apparatus for determining densities of solids, liquids and gases. The apparatus includes, besides balances, a microscope, a spectroscope, a polariscope, a photometer, a barometer, and numerous models and sets of apparatus. The various rooms are furnished with an extensive collection of industrial charts. A valuable and growing collection of specimens and samples, fitted to illustrate different subjects taught, is also provided. This includes rocks, minerals, soils, raw and manufactured fertilizers, foods, including milking products, fibres and other vegetable and animal products, and artificial preparations of mineral and organic compounds. Series of preparations are used for illustrating the various stages of different manufactures from raw materials to finished product.

Geology.

Geological teaching is illustrated by a very complete series of minerals, the State collection of rocks of Massachusetts, a series of Ward's fossils and casts of fossils, models and charts.

Zoölogy.

Sophomore Laboratory. — A large, well-lighted room, situated in the old chapel building, is fitted with tables and apparatus, such as microscopes, dissecting instruments and the like, which are necessary for a beginners' course in zoölogical dissection.

Advanced Laboratory. — The room formerly used as a lecture room has been fitted up as a laboratory for advanced students. It is in South College, adjacent to the museum, and is amply supplied with the best apparatus obtainable. The equipment includes compound and simple microscopes, dissecting instruments and trays, an incubator, paraffin bath, microtomes, etc., also a reference library, containing the current zoölogical journals and a good series of mounted slides for the microscope.

Zoölogical Lecture Room. — The department has the privilege of using the philosophical lecture room, which communicates directly with the advanced laboratory. The lecture equipment includes, besides the museum specimens, the Leuckart series of charts, and many specially made charts as well; the Auzoux

models, illustrative of human and comparative anatomy; and an electric stereopticon.

Museum of Zoölogy. — The museum is mainly for the purpose of exhibiting those forms treated of in the lecture and laboratory courses, but, in addition to this, the aim has been to show as fully as possible the fauna of the Commonwealth, and those types which show the evolution and the relationship of the members of the animal kingdom. The total number of specimens contained in the museum now exceeds eleven thousand. The museum is open to the public from 3.30 to 5.30 P.M. each week day.

Entomological Laboratory. — The equipment for work in entomology during the senior year and for graduate students is unusually good. The laboratory building contains a large room for laboratory work, provided with tables, dissecting and compound microscopes, microtomes, reagents and glass ware. One portion of the building is fitted up as a lecture room. Another room is devoted to library purposes, and contains a card catalogue of over fifty thousand cards, devoted to the literature of insects. In addition to a well-selected list of entomological works in this room, the college library has an unusual number of rare and valuable books on this subject. This is supplemented by the private entomological library of the professor in charge, which contains over twenty-five hundred volumes, many of which cannot be found elsewhere in the United States. In another room is a large and growing collection of insects, both adult and in the early stages, which is of much assistance to the students. As the laboratory is directly connected with the insectary of the Hatch Experiment Station, the facilities of the latter are directly available. The apparatus room of the insectary, with its samples of spray pumps, nozzles and other articles for the practical treatment of insects; the chemical room fitted up for the analysis of insecticides and other chemico-entomological work; and a greenhouse, where plants infested by injurious insects are under continual observation and experimental treatment, — all these are available to the student. In addition, several private laboratory rooms and a photographing room with an unusually good equipment of cameras are provided. The large greenhouses, grounds, gardens and orchards of the college are also to be mentioned under this head, providing, as they do, a wide range of subjects for study of the attacks of injurious insects under natural conditions.

Veterinary Science.

The department has for its sole use a commodious and modern laboratory and hospital stable, erected in 1899. Both buildings are constructed according to the latest ideas as regards sanitation. Every precaution has been taken in the arrangement of details to prevent the spread of disease, and to provide for effective heating, lighting, ventilation and disinfection.

The laboratory building contains a large working laboratory for student use, and several small private laboratories for special work. In addition, there is a lecture hall, museum, demonstration room, photographing room and work shop. The hospital stable contains a pharmacy, operating hall, post-mortem and disinfecting room, besides a section for poultry, one for cats and dogs, and six sections, separated from each other, for the accommodation of horses, cattle, sheep, swine and other domestic animals.

The laboratory equipment consists of a dissecting Auzoux model of the horse, Auzoux models of the foot and the legs, showing the anatomy and the diseases of every part. There are skeletons of the horse, cow, sheep, dog and pig, and, in addition, a growing collection of anatomical and pathological specimens. The lecture room is provided with numerous maps, charts and diagrams, which are made use of in connection with lectures and demonstrations.

The laboratories are supplied with the most modern high-power microscopes, microtomes, incubators and sterilizers, for the use of students taking the work in bacteriology and parasitology.

Botany.

The botanical department possesses a general laboratory, furnished with tables and benches for microscopical and physiological work, and with a dark closet for photographic purposes. There are forty compound microscopes, twenty-three dissecting microscopes, a micro-photographic and landscape camera and various accessories; also microtomes, paraffin baths, etc., for histological work; a large and useful collection of physiological apparatus for the study of photo-synthesis, respiration, metabolism, transpiration, heliotropism, geotropism, hydrotropism, galvanotropism, chemotropism, and other irritable phenomena connected with plants; a set of apparatus for the study of the mechanical constituents of the soil, and for experimental work in soil physics; a large and unique outfit of electrical appliances for the study of all phenomena related to electricity and plant growing; various devices for the study of

mechanics of plant structure; numerous contrivances to determine the power exerted by living plant organisms; several types of self-registering auxanometers, used to measure the rate of growth of plants; self-registering thermometers, and hygrometers for recording constant changes in conditions.

A small special laboratory for graduate students is equipped with microscopes and other apparatus and reagents for advanced work.

Botanical Lecture Room. — The botanical lecture room adjoining the laboratory is adapted for general work in morphology and flower analysis, with opportunity to use dissecting microscopes. It contains a movable chart system, arranged to display over three thousand figures relating to the structure and function of plants.

Mathematics, Physics and Engineering.

Surveying. — The department possesses a considerable number of the usual surveying instruments, with the use of which the students are required to become familiar by performing a required amount of field work. Among the larger instruments are two plain compasses, railroad compass with telescope, surveyor's transit, two engineer's transits with vertical arc and level, solar compass, omnimeter with verniers reading to ten seconds, adapted to geodetic work, Queen plane table, two wye levels, dumpy level, builder's level, sextant, hand level, and a large assortment of levelling rods, flag poles, chains, tapes, etc. For draughting, a vernier protractor, pantograph, parallel rule, etc., are available.

Physics. — Among the apparatus in use for general instruction in general physical processes may be found a set of United States standard weights and measures, precision balances, spherometer, vernier calipers, etc.; in mechanics, apparatus to illustrate the laws of falling bodies, systems of pulleys and levers, motion on an incline plane, and the phenomena connected with the mechanics of liquids and gases. The usual apparatus for lecture illustration in heat, light and sound are also in the possession of the department. In electricity, the equipment consists of apparatus for both lecture illustration and laboratory work, among which may be enumerated a full set of Weston ammeters and volt meters, a Carhart-Clark standard cell, Mascart quadrant electrometer, Siemens electro-dynamometer, as well as reflecting galvanometers and Wheatsone bridges for ordinary determinations of currents and resistance.

Military Science.

In addition to a large campus, suitable for battalion drill, the military department possesses a special building in which there is a drill room 60 by 135 feet, an armory, a recitation room, an office for the commandant, and a field gun and gallery practice room. The building also has a large bathroom immediately adjoining the armory.

In a plot of ground north of the college building there is a rifle range, marked for practice at distances of 100 and 200 yards. The range is furnished with a revolving target suitably protected by earthworks. The national government supplies, for the use of the department, arms and equipments; the Springfield cadet rifle and two breech-loading rifled steel guns, calibre 3.2, with complete equipments and ammunition.

The State supplies instruments for the college band.

Students are held responsible for all articles of public property while in their possession.

The Chapel-Library Building.

One of the most attractive and commodious buildings belonging to the college is the chapel-library. It has a commanding position, approximately in the centre of the group of buildings adjoining the campus. The chapel occupies the entire second story. A large room, capable of seating about four hundred, is used for daily prayers, Sunday services, the various commencement exercises, and not infrequently for lectures or social gatherings. The room has an excellent pipe organ. Two adjoining rooms are used for small religious gatherings, and meetings of the class teachers and of the faculty. The rooms can be thrown open so as to become a part of the main audience hall.

The entire lower story is given over to the library. This library is available for reference or investigation, and is open daily, except on Sundays, from 8 A.M. to 5 P.M. and from 6.30 to 8.30 P.M. It is open on Sundays from 10 A.M. to 1 P.M. The volumes at present number 25,829. The library contains carefully selected books in the departments of agriculture, horticulture, botany, entomology and other natural sciences. Sociology, economics, history, literature, the fine arts and the useful arts are well represented. Constant additions will be made to secure the latest and best works in the several departments of learning.

Dining Hall.

A colonial dining hall, built of brick and equipped with all modern conveniences, was completed and opened February, 1903, for the accommodation of students. A committee composed of two members of the faculty, two members of the student body, and the steward, manages the affairs of the dining hall.

The hall contains a number of suites of rooms which may be secured for occupancy by young women attending any of the departments of the college.

The Heating, Lighting and Power Plant.

This plant is located in the ravine, near the chemical laboratory. It is equipped with two large boilers, an engine and an electric generator. Here steam is generated which heats the college buildings on the west side of the public highway, extending from the dining hall to the veterinary laboratory. Here also is produced the electricity which lights all the buildings and the grounds of the college. Electric power is also generated which is used to drive the machinery in the dairy and in the barn. Connected with the plant is a machine shop in which much work is done for the college. The plant affords opportunity for students in mechanical and electrical engineering to observe the modern utilization of steam and electricity.

EXPENSES.

Tuition. — Tuition is free to citizens of the United States. Citizens of Massachusetts, however, in accordance with an act of the Legislature, must make application to the Senator of the district in which they live for a free scholarship that covers the charge for tuition. Blank forms for such application may be obtained from the president of the college.

Rooms. — It is expected that students will occupy rooms in the college dormitories, unless excused to room elsewhere. For the information of those desiring to carpet their rooms, the following measurements are given: in the south dormitory the study rooms are about fifteen by fourteen feet, with a recess seven feet four inches by three feet; and the bedrooms are eleven feet two inches by eight feet five inches. In the north dormitory the corner rooms are fourteen by fifteen feet, and the annexed bedrooms eight by ten feet. The inside rooms are thirteen and one-half by fourteen

and one-half feet, and the bedrooms eight by eight feet. All rooms are unfurnished. Mr. Thomas Canavan has the general superintendence of the dormitories, and all correspondence relative to the engaging of rooms should be with him.

Board. — Board at the new dining hall has been $3.25 per week; in private families, $4 to $5.

Incidental Expenses. — The military suit must be obtained immediately upon entering college, and used in the drill exercises prescribed. The following fees, to be paid in advance, are applied towards the maintenance of the several laboratories: chemical, $15 per semester used; zoölogical, $2 per semester used sophomore year, other classes $4 per semester; entomological, $3 per semester used. The fee for use of the botanical laboratory for one period of two hours during each week is $1 per semester; other periods will be charged for proportionally. Some expense is also incurred for text-books. In exceptional cases incidental expenses necessitate additional charges.

Room rent, in advance,	$15 00	$45 00
Board, $3.25 to $4 per week,	117 00	144 00
Fuel,	12 00	12 00
Washing, 30 to 60 cents a week,	11 00	22 00
Military suit,	12 50	20 00
Lights,	12 00	12 00
Miscellaneous,	41 00	45 00
	$220 50	$300 00

In addition to the above expenses, $120 tuition is charged to foreigners.

SCHOLARSHIPS.

Established by Private Individuals.

Mary Robinson Fund of one thousand dollars, the bequest of Miss Mary Robinson of Medfield.

Whiting Street Fund of one thousand dollars, the bequest of Whiting Street, Esq., of Northampton.

Henry Gassett Fund of one thousand dollars, the bequest of Henry Gassett, Esq., of North Weymouth.

The income of the above funds is assigned by the faculty to worthy students requiring aid.

Congressional Scholarships.

The trustees voted in January, 1878, to establish one free scholarship for each of the congressional districts of the State. Application for such scholarships should be made to the representative from the district to which the applicant belongs. The selection for these scholarships will be determined as each member of Congress may prefer; but, where several applications are sent in from the same district, a competitive examination would seem to be desirable. Applicants should be good scholars, of vigorous constitution, and should enter college with the intention of remaining through the course.

State Scholarships.

The Legislature of 1883 passed the following resolve in favor of the Massachusetts Agricultural College: —

Resolved, That there shall be paid annually, for the term of four years, from the treasury of the Commonwealth to the treasurer of the Massachusetts Agricultural College, the sum of ten thousand dollars, to enable the trustees of said college to provide for the students of said institution the theoretical and practical education required by its charter and the law of the United States relating thereto.

Resolved, That annually for the term of four years eighty free scholarships be and hereby are established at the Massachusetts Agricultural College, the same to be given by appointment to persons in this Commonwealth, after a competitive examination, under rules prescribed by the president of the college, at such time and place as the senator then in office from each district shall designate; and the said scholarships shall be assigned equally to each senatorial district. But, if there shall be less than two successful applicants for scholarships from any senatorial district, such scholarships may be distributed by the president of the college equally among the other districts, as nearly as possible; but no applicant shall be entitled to a scholarship unless he shall pass an examination in accordance with the rules to be established as hereinbefore provided.

The Legislature of 1886 passed the following resolve, making perpetual the scholarships established: —

Resolved, That annually the scholarships established by chapter forty-six of the resolves of the year eighteen hundred and eighty-three be given and continued in accordance with the provisions of said chapter.

In accordance with these resolves, any one desiring admission to the college can apply to the senator from his district for a scholarship. Blank forms of application will be furnished by the president.

THE LABOR FUND.

The object of this fund is to assist those students who are dependent either wholly or in part on their own exertions, by furnishing them work in the several departments of the college. The greatest opportunity for such work is found in the agricultural and horticultural departments. Application should be made to Profs. William P. Brooks and Frank A. Waugh, respectively in charge of said departments. Students desiring to avail themselves of its benefits must bring a certificate signed by one of the selectmen of the town in which they are resident, certifying to the fact that they require aid.

PRIZES.

Burnham Rhetorical Prizes.

These prizes are awarded for excellence in declamation, and are open to competition, under certain restrictions, to members of the sophomore and freshman classes.

Flint Prizes.

Mr. Charles L. Flint of the class of 1881 established two prizes, one of thirty dollars and another of twenty dollars, to be awarded, at an appointed time during commencement week, to the two members of the junior class who may produce the best orations. Excellence in both composition and delivery is considered in making the award.

Notwithstanding the death of Mr. Flint, in June, these prizes will be continued under the name of the Flint prizes.

Grinnell Agricultural Prizes.

Hon. William Claflin of Boston has given the sum of one thousand dollars for the endowment of a first and second prize, to be called the Grinnell agricultural prizes, in honor of George B. Grinnell, Esq., of New York. These two prizes are to be paid in cash to those two members of the graduating class who may pass the best written and oral examination in theoretical and practical agriculture.

Hills Botanical Prizes.

The Hills prizes of thirty-five dollars, given by the late Henry F. Hills of Amherst, will this year be awarded to members of the senior class as follows: fifteen dollars for the best general her-

barium; ten dollars for the best collection of Massachusetts trees and shrubs; and ten dollars for the best collection of Massachusetts woods.

Winter Course Prizes.

The dairy prizes, given by the Massachusetts Society for Promoting Agriculture, to members of the short winter course. Two sets of prizes are offered: the first set consists of three prizes of fifty, thirty and twenty dollars, respectively, given for general excellence in all branches of the course as offered; the second set consists of three prizes of twenty-five, fifteen and ten dollars, respectively, for excellence in the making of butter.

Award of Prizes, 1904.

Grinnell Agricultural Prizes (*Senior*). — First prize, Arthur Witter Gilbert; second prize, Sidney Burritt Haskell.

Hills Botanical Prizes (*Senior*). — First and second prizes, Ernest Adna Back.

Flint Oratorical Prizes (*Junior*). — First prize, George Howard Allen; second prize, Albert Davis Taylor.

Burnham Essay Prizes (*Sophomore*). — First prize, Arthur Alphonse Racicot, Jr.; second prize, Edwin Hobart Scott; third prize, Frank Augustus Ferren.

Burnham Declamation Prizes (*Freshman*). — First prize, Charles Arthur Allenham Rice; second prize, George Whitney Searle.

Military Honors (*Senior*). — The following cadets were reported to the Adjutant-General, U. S. A., and to the Adjutant-General of Massachusetts, as having shown special aptitude for military service: Fayette D. Couden, Howard M. White, Clarence H. Griffin.

Winter Course in Dairy Farming. — Massachusetts Society for Promoting Agriculture: for general excellence, first prize, $50, Charles H. Thayer; second prize, $30, Gordon Runkle; third prize, $20, Fred S. Farwell.

Massachusetts Society for Promoting Agriculture: for highest scoring tub butter, first prize, $25, Chester D. Abbott; second prize, $15, Albert W. Mead; third prize, $10, Alvah G. Eldridge.

Massachusetts Society for Promoting Agriculture: for excellence in stock judging, first prize, $10, Fred M. Pick; second prize, $7.50, Gordon Runkle; third prize, $5, Homer G. Phillips; fourth prize, $2.50, Chester L. Shaw.

The Vermont Farm Machine Company of Bellows Falls, Vt.:

for highest scoring print butter, first prize, $15; Albert W. Mead; second prize, $10, Alvah G. Eldridge.

Special prize, offered by W. H. Bowker of Boston, for best knowledge of the use of fertilizers on the farm, one-half ton Stockbridge fertilizer, Gordon Runkle.

Special prize, given by B. von Herff of New York, for best knowledge of the use of fertilizers on grass lands, one ton kainite, Gordon Runkle.

RELIGIOUS SERVICES.

Chapel services are held every week day at 8 A.M. Further opportunities for moral and religious culture are afforded by Bible classes taught by one of the professors and other teachers for an hour every Sunday afternoon, and by a religious meeting Thursday evening under the auspices of the College Young Men's Christian Association.

LOCATION.

Amherst is on the New London Northern Railroad, connecting at Palmer with the Boston & Albany Railroad, and at Millers Falls with the Fitchburg Railroad. It is also on the Central Massachusetts Railroad, connecting at Northampton with the Connecticut River Railroad and with the New Haven & Northampton Railroad.

The college buildings are on a healthful site, commanding one of the finest views in New England. The large farm of four hundred acres, with its varied surface and native forests, gives the student the freedom and quiet of a country home.

REPORTS.

TREASURER'S REPORT.

RECEIPTS AND EXPENDITURES FOR YEAR, JAN. 1 TO DEC. 21, 1904.

RECEIPTS.

State Treasurer, Morrill fund,		$16,666 66	
Endowment fund,		10,127 12	
Maintenance appropriation,		5,000 00	
Instruction appropriation,		11,750 00	
Scholarship appropriation,		13,750 00	
Labor appropriation,		5,000 00	
Special for deficit in coal in 1903,		3,500 00	
Heating and lighting maintenance,		375 00	
Dining-hall maintenance,		375 00	
Labor fund,		19 29	
Library fund,		641 10	
Burnham emergency fund,		150 00	
Botanical laboratory,		117 00	
Chemical laboratory,		652 14	
Entomological laboratory,		58 23	
Veterinary laboratory, appropriation,	$500 00		
Cash,	15 75		
		515 75	
Zoölogical laboratory,		102 50	
Landscape gardening tax,		54 50	
Term bill,		4,065 49	
Heating and lighting,		2,060 72	
Agricultural department,		875 45	
Farm,		6,730 12	
Horticultural department,		4,881 12	
Expense,		880 68	
Tools and implements,		1 01	
Furniture,		3 00	
			$88,351 88

EXPENDITURES.

Labor fund,	$4,955 97	
Library,	3,108 08	
Botanical laboratory,	137 74	
Chemical laboratory,	185 63	
Amount carried forward,	$8,387 42	

Amount brought forward,	$8,387 42	
Entomological laboratory,	111 49	
Veterinary laboratory,	1,156 93	
Zoölogical laboratory,	284 61	
Landscape gardening,	28 90	
Burnham emergency fund,	125 00	
Salary,	30,910 48	
Extra instruction,	185 00	
Term bill,	1,372 89	
Advertising,	450 20	
Heating and lighting,	8,080 22	
Agricultural department,	1,913 68	
Farm,	10,561 45	
Horticultural department,	8,487 44	
Expense,	8,850 26	
Insurance,	15 00	
Tools and implements,	7 75	
Furniture,	235 97	
Dining hall, 1903,	3,774 16	
Dining hall, 1904,	3,669 52	
Total expenditures,		$88,608 37
Total receipts,		88,351 88
Excess of expenditures over receipts,		$256 49

CASH ACCOUNT.

Dr.

Cash on hand Jan. 1, 1904,	$6,754 70

Cr.

Cash on hand and in local bank Dec. 21, 1904,	$4,698 21	
Deposit with Hampden Trust Company,	1,800 00	
Excess of expenditures over receipts,	256 49	
		$6,754 70

INVENTORY — REAL ESTATE.

Land (Estimated Value).

College farm,	$37,000 00	
Pelham quarry,	500 00	
Bangs place,	2,350 00	
Clark place,	4,500 00	
		$44,350 00

Buildings (Estimated Value).

Drill hall,	$5,000 00	
Powder house,	75 00	
Gun shed,	1,500 00	
Amounts carried forward,	$6,575 00	$44,350 00

Amounts brought forward,	$6,575 00	$44,350 00
Stone chapel,	30,000 00	
South dormitory,	35,000 00	
North dormitory,	25,000 00	
Chemical laboratory,	8,000 00	
Entomological laboratory,	3,000 00	
Veterinary laboratory and stable,	22,500 00	
Farmhouse,	2,000 00	
Horse barn,	5,000 00	
Farm barn and dairy school,	33,000 00	
Graves house and barn,	1,500 00	
Boarding house,	1,000 00	
Dining hall,	35,000 00	
Botanic museum,	5,500 00	
Botanic barn,	2,500 00	
Tool house,	2,000 00	
Durfee plant house and fixtures,	13,000 00	
Small plant house, with vegetable cellar and cold grapery,	4,700 00	
President's house,	6,500 00	
Dwelling houses purchased with farm,	5,000 00	
		246,775 00
		$291,125 00

EQUIPMENT.

Botanical department,	$4,310 00	
Horticultural department,	14,113 89	
Farm,	17,912 58	
Chemical laboratory,	1,775 00	
Botanical laboratory,	2,866 53	
Entomological laboratory,	15,425 00	
Zoölogical laboratory,	3,286 00	
Zoölogical museum,	6,103 00	
Veterinary laboratory,	6,004 46	
Physics and mathematics,	3,848 60	
Agricultural department,	3,500 00	
Agricultural laboratory,	1,300 00	
Library,	25,973 00	
Fire apparatus,	400 00	
Band,	350 00	
Furniture,	1,400 00	
Text-books,	300 00	
Tools, lumber and supplies,	252 00	
Heating and lighting,	53,423 00	
Dining hall,	5,000 00	
		$167,543 06

BALANCE SHEET DEC. 21, 1904.

Assets.

Real estate,		$291,125 00	
Equipment,		167,543 06	
			$458,668 06

Quick Assets.

Bills receivable: —			
Farm,	$245 84		
Horticulture,	497 93		
Heating and lighting,	846 06		
Rents and text-books,	813 15		
Laboratory fees,	478 00		
Dining hall,	534 50		
Mary Robinson fund,	36 76		
Whiting Street fund,	5 24		
		$3,457 48	
Notes,		72 00	
Cash on hand and in local bank,		4,698 21	
Hampden Trust Company,		1,800 00	
			10,027 69
			$468,695 75

Liabilities.

Bills payable: —			
Farm,	$1,401 54		
Horticulture,	392 66		
Expense,	74 09		
Heating and lighting,	846 65		
Library,	221 25		
Furniture,	49 75		
Laboratories,	17 11		
Due Gassett scholarship,	22 00		
Due Grinnell prize,	66 24		
Due Hills fund,	462 43		
Due Burnham emergency,	135 56		
Due labor fund,	371 01		
Due individual labor,	349 72		
Due veterinary laboratory,	154 82		
		$4,564 83	
Burnham emergency fund,		3,000 00	
			7,564 83
Balance,			$461,130 92

INVESTMENT.

Endowment Fund.

United States grant,	$219,000 00	
Commonwealth grant,	142,000 00	
		$361,000 00

This fund is in the hands of the State Treasurer, and the Agricultural College receives two-thirds of the income from the same (for amount of income, see college receipts).

Individual Labor Fund.

Two bonds American Telephone and Telegraph 4s,	$2,000 00	
One bond New York Central debenture 4s,	1,000 00	
Hampden Trust Company,	1,500 00	
Cash,	500 00	
		$5,000 00

Hills Fund.

Northampton Institution for Savings,	$2,180 00	
One bond American Telephone and Telegraph 4s,	1,000 00	
Three American Telephone notes, 5 per cent.,	3,000 00	
One bond New York Central debenture 4s,	1,000 00	
One bond New York Central & Lake Shore 3½s,	1,000 00	
Boston & Albany Railroad stock,	362 00	
		$8,542 00

Burnham Emergency Fund.

Northampton Institution for Savings,	$2,000 00	
Massachusetts Agricultural College note,	3,000 00	
		$5,000 00

(For amount of income, see college receipts.)

Mary Robinson Fund.

Northampton Institution for Savings,	$820 00	
Boston & Albany Railroad stock,	38 00	
		$858 00

Whiting Street Fund.

One bond New York Central debenture 4s,	$1,000 00	
Amherst Savings Bank,	260 00	
		$1,260 00

Gassett Scholarship Fund.

One bond New York Central debenture 4s,	$1,000 00

Grinnell Prize Fund.

Ten shares New York Central & Hudson River Railroad stock,	$1,000 00

Massachusetts Agricultural College.

One share New York Central & Hudson River Railroad stock,	$100 00

Library Fund.

Amherst Savings Bank,	$10,546 12

(For amount of income, see college receipts.)

INVESTMENT CASH ACCOUNT.

FUND.

Receipts.

Hampden Trust Company, individual labor fund,	$3,000 00	
Northampton Institution for Savings, Hills fund,	$4,000 00	
Agawam National Bank, Hills fund,	2,000 00	
	6,000 00	
Amherst Savings Bank, Whiting Street fund,	1,000 00	
Amherst Savings Bank, Gassett scholarship fund,	1,000 00	
Coupons American Telephone notes, (Toward payment in premium of same.)	75 00	
Cash, individual labor fund,	500 00	
		$11,575 00

Expenditures.

Two bonds, individual labor fund,	$1,859 00	
One bond, individual labor fund,	997 61	
One bond, Hills fund,	969 67	
Two notes, Hills fund,	3,113 75	
One bond, Hills fund,	1,010 08	
One bond, Hills fund,	908 75	
One bond, Whiting Street fund,	988 36	
One bond, Gassett scholarship fund,	988 36	
		10,835 58
Excess of receipts over expenditures,		$739 42

INCOME.

Receipts.

Individual labor fund,	$103 80	
Hills fund,	363 43	
Mary Robinson fund,	34 07	
Whiting Street fund,	45 20	
Gassett scholarship fund,	40 00	
Grinnell prize,	50 00	
Massachusetts Agricultural College,	5 00	
		$641 50

Expenditures.

Individual labor fund,	$16 25	
Hills fund,	106 16	
Mary Robinson fund,	91 20	
Whiting Street fund,	71 64	
Gassett scholarship fund,	66 16	
Grinnell prize,	55 00	
		406 41
Excess of receipts over expenditures,		$235 09

This is to certify that I have examined the accounts of George F. Mills, treasurer of Massachusetts Agricultural College, for the year ending Dec. 21, 1904. All bonds and investments are as represented in the report. All disbursements are properly vouched for, and all cash balances are found to be correct.

CHARLES A. GLEASON,
Auditor.

Amherst, Dec. 23, 1904.

GIFTS.

From W. H. Bowker (M. A. C., '71), Boston, one-half ton high-grade Stockbridge fertilizer, for prize in dairy school.

Massachusetts Society for Promoting Agriculture, Boston, one hundred and seventy-five dollars in prizes for dairy school.

B. von Herff, New York, one ton kainite, for prize in dairy school.

Vermont Farm Machine Company, Bellows Falls, Vt., twenty-five dollars in prizes for dairy school.

National Milk Sugar Company, New York, four hundred pounds milk albumen.

Chilean Nitrate Works, New York, four thousand pounds nitrate of soda.

S. M. Barnard Company, Forestville, Conn., two stanchions.

Cyphers Incubator Company, Buffalo, N. Y., one gallon napcreol.

Stoddard Manufacturing Company, Rutland, Vt., one gallon turbine separator oil.

Mt. Tom Sulphite Pulp Company, Mt. Tom, seventy pounds wood pulp.

J. A. Bennett & Son, Gouverneur, N. Y., one incubator, one brooder.

Joseph Breck & Sons, Boston, one incubator, one brooder.

M. Campbell Fanning Mill Company, Detroit, Mich., one incubator, one brooder.

John R. Clisby, Arcola, Ill., eight ears seed corn.

Edmund Mortimer & Co., New York, one ton Peruvian guano.

Chemical Works, late H. & E. Albert, London, Eng., two tons basic slag.

Wesson Stanchion Company, Cuba, N. Y., two stanchions.

W. T. Snow, Westfield, fifty pounds bone charcoal.

Seed Laboratory, United States Department of Agriculture, Washington, D. C., two sets of seeds in vials.

From German Kali Works, New York, thirty-five hundred pounds potash-magnesia sulfate; twenty-five hundred pounds high-grade sulfate; five thousand pounds muriate; one hundred pounds silicate; two hundred and twenty-four pounds carbonate; five hundred pounds kainite.

Peter Henderson & Co., New York, twenty-six varieties of grass seed, seven of clover, seven of oats, four of barley, one of rye.

D. H. Burrill & Co., Little Falls, N. Y., paint, varnish and transfers for eight testers.

C. S. Plumb (M. A. C., '82), Columbus, O., herbarium containing one thousand species native American plants.

Wallace R. Pierson (M. A. C., '01), Cromwell, Conn., one hundred and sixty rose plants.

Mrs. Annie Trumbull Slosson, New York, collection of Florida Hemiptera.

R. A. Cooley (M. A. C., '95), Bozeman, Montana, J. R. de la Torre Bueno, New York, and others, insects.

Mrs. Charles L. Flint, Brookline, collection of zoölogical specimens, minerals and curios.

Esther C. Cushman (M. A. C., '05), Amherst, partridge.

Harold E. Hodgkiss (M. A. C., '02), Wilkinsonville, horned toad.

Loans.

From Empire Cream Separator Company, Bloomfield, N. J., two separators.

P. M. Sharples, West Chester, Pa., three separators.

National Dairy Machine Company, Newark, N. J., one separator and stand.

Vermont Farm Machine Company, Bellows Falls, Vt., five separators, one tester.

De Laval Separator Company, New York, six separators.

Des Moines Incubator Company, Des Moines, Ia., one incubator, one brooder.

Humphrey & Sons, Joliet, Ill., one brooder.

Stoddard Manufacturing Company, Rutland, Vt., combined churn and butter-worker, pasteurizer.

FARM REPORT.

During the past year a change has been made in the management of the college farm. Mr. E. A. Jones, who had faithfully discharged the duties of farm superintendent for ten years, sent in his resignation in March, to take effect on the first of May. His place was taken on this date by E. H. Forristall, M.S., of the New Hampshire Agricultural College, who at one time successfully superintended the college farm of that institution, and later accepted and filled the position of superintendent on one of the farms managed for the production of high-grade milk by the Walker-Gordon Company. Mr. Forristall has taken hold of the work of his position with much enthusiasm. It would be manifestly unfair to judge his work on the basis of the results obtained during the past season, for he had not the advantage of beginning as early as would have been desirable, and the season, like those of the two previous years, has been highly unfavorable to success with some of our most important crops. The excessive rainfall during the period from about the 1st of April to the 7th of June, and the abnormally low summer temperatures, are conditions responsible for the partial failure of all crops requiring a long and warm season. The effects of the seasonal peculiarities referred to were greatly aggravated by the fact that the first killing frost came fully three weeks earlier than is usual in this section (September 22). The corn crop, which, on account of the excessive wetness of many of our fields, was not all planted until after the middle of June, was seriously injured by this early freeze. The crops of the year which have given best returns are hay, roots and celery. All of these gave results better than average, both as regards quantity and quality. The nature of the farm operations and the financial results with the several crops are shown in the following table: —

College Farm Crops.

CROPS.	Acres.	Total Product.		Cost.		Value.	Net Profit.	Loss.
		Bushels.	Tons.	Manure.	Labor and Seed.			
Celery,	1	170 doz. bunches.	–	$10 47	$53 45	$229 50	$154 58	–
Carrots,	⅓	251	–	11 23	15 00	125 50	99 27	–
Mangels,	⅓	–	23⅓	11 23	15 90	116 66	89 53	–
Turnips,	–	138	–	–	28 10	34 50	6 40	–
Ensilage corn,	22	–	300	288 70	443 90	1,050 00	317 40	–
Field corn,	8	465 hard. 75 soft.	Stover 22	121 50	259 40	585 60	204 50	–
Potatoes,	8	725 large. 300 small.	–	159 50	443 90	451 01	–	$152 39
Hay,	71	–	190	–		2,376 00	–	–
Rowen,	–	–	60	–	482 55	960 00	–	–
Rowen pastured,	–	–	10	–		50 00	–	–
Oats and peas, green,	1	–	15	–	31 00	45 00	–	–

The System followed in the Use of Manures and Fertilizers.

The manures and fertilizers used for the several crops of the year are shown in the table on the following page. It is our practice to haul manure from the pits in which it accumulates at frequent intervals, and, as a rule, it is spread when hauled. Much of the manure used accordingly lies upon the surface several months. On old land it is plowed under in spring. If applied to sod land, which has been fall plowed, the manure is worked into the ground with a disc harrow in spring. The fertilizers used for the several hoed crops are for the most part spread broadcast after the field is plowed, and harrowed in, although it is our practice to use a moderate amount of nitrate of soda together with a little acid phosphate and potash in the drill. The potato crop is in some respects an exception. We find that with this better results are obtained if a larger proportion of the fertilizer is applied in the drill; and, as a rule, about two-thirds of the total amount is so applied. The fertilizers used on grass lands are applied in mid-spring by the use of the Stevens broadcast fertilizer distributer.

Manures and Fertilizers for the Several Crops per Acre.

	Corn, Campus, Two Acres.	Corn, Eight Acres.	Corn, Ensilage, Twelve Acres.	Field Corn.	Mangels, One-third Acre.	Carrots, One-third Acre.	Potatoes, Eight Acres.
Manure (cords),	–	3	3	2	4	4	4
Nitrate of soda (pounds),	100	100	125	125	200	200	100
High-grade sulfate of potash (pounds),	150	125	150	150	–	–	250
Phosphatic slag (pounds),	500	300	500	500	600	600	–
Lime (pounds),	–	–	–	2,000	–	–	–
Muriate of potash (pounds),	–	–	–	–	350	350	–
Dried blood (pounds),	–	–	–	–	–	–	150
Tankage (pounds),	–	–	–	–	–	–	250

Experiments in the Use of Manures and Fertilizers.

A. Method of Application of Barnyard Manure.

On the grounds of the experiment station we have for a number of years been comparing two systems of handling manures; namely, spreading the fresh manure upon the surface of the ground during the late fall and winter months, in comparison with the system of putting the fresh manure as made during the winter into large heaps, from which it is taken in the spring when the land is ready to plow. The manure in both cases is plowed in, but that spread in winter lies on the surface a variable time, from an extreme period of five months to a few weeks only. The field in the experiment station grounds where these two systems are under comparison is one with a considerable slope. It seemed desirable to compare these same methods upon level land, and a field suited to that purpose was found on the grounds of the college farm. Two plots of one acre each were laid out in the autumn of 1901. The crops of the two following seasons were corn, and for both years the yield of corn on the winter-spread manure was slightly greater than on that spread in the spring. The crop during the past season also was corn for the silo. The yield on the acre on which the manure was spread in winter was 43,855 pounds: on the acre on which it was spread in the spring, 27,240 pounds. The advantage appears to be largely in favor of winter spreading; but, although it is impossible to point to any accidental variation in conditions on the two plots, it seems difficult to believe that the difference in the time of spreading the manure should be responsible for so great a difference in the crops.

B. Experiment in the Use of Fertilizers on Permanent Mowings.

On different portions of the college campus, which is kept permanently in grass, we have laid out a considerable number of plots to which various combinations and amounts of fertilizers have been applied. Nitrate of soda is used alone on a few plots, a potash salt and basic slag on a number of others, a potash salt and basic slag and varying quantities of nitrate of soda on still others. The continuous use of nitrate of soda alone has produced a fair crop of hay, which consists exclusively of grasses. In a half-acre plot, to which nitrate of soda alone has been applied since 1899, there is at present scarcely a single clover plant. On an adjoining plot, with soil of precisely the same character, to which at first potash alone was applied, and to which for the past two years muriate of

potash and basic slag have been applied, clovers predominate. On those plots to which a potash salt and basic slag together with nitrate of soda is applied, there is a considerable proportion of clover, and the crops have been very satisfactory. During the past season the usual rate of application has been: muriate or high-grade sulfate of potash, 150 pounds; basic slag, 500 pounds, per acre; and with these amounts of potash and slag we have used nitrate of soda on different plots in quantities ranging from 150 to 250 pounds per acre. The larger applications of nitrate in general gave most profitable crops, although in one of our fields extensive lodging was the consequence whenever nitrate was applied in quantities in excess of 200 pounds to the acre.

Live Stock.

The general average of health maintained by our live stock during the past year has been good. We have lost one valuable horse, which was found dead in the morning with a ruptured stomach, no doubt the consequence of an attack of colic. One breeding sow was found dead, and post-mortem examination revealed internal hemorrhage as the apparent cause of death. The presence of a skewer in swill fed to our hogs caused the death of another. The kinds and numbers of the several classes of live stock are shown below: —

Horses. — French Coach, 1 stallion, 1 mare, 3 fillies; Percheron, 1 stallion; German Coach, 1 mare; French Coach, half blood, 2 colts; Percheron, three-fourths blood, 2 mares, 1 yearling gelding; work horses, 3.

Neat Cattle. — Jersey, 1 bull, 4 cows, 2 heifers, 1 calf; Holstein-Friesian, 1 bull, 4 cows; Ayrshire, 1 bull, 4 cows; Shorthorn, 1 bull, 1 cow; grade, 32 cows, 9 heifers, 12 calves; 1 Jersey bull calf; total, 74 head.

Sheep. — Southdown, 4 breeding bucks, 50 ewes, 2 lambs; total, 56 head.

Swine. — Berkshire, 1 boar, 5 sows; Yorkshire, 5 sows; shoats, 47; total, 58 head.

The Milk Record.

The policy of disposing of the least satisfactory cows in our herd has been continued during the past year, and a few superior grade cows have been purchased. The average product for the year shows a marked improvement, as compared with recent years. The average number of cows milked during the year is $35\frac{1}{6}$. The total yield of milk has been 232,463 pounds, — an average

per cow of 6,610 pounds. The average butter fat test for the herd is about 4.2 per cent., which makes an average yield of butter fat per individual cow of 277.62 pounds, which is the equivalent of about 319 pounds of butter per cow per year.

Improvements.

The principal improvements of the past year are as follows: —

About two additional acres in Durfee pasture have been cleared of stumps, and most of this is plowed and ready for a crop. The four acres which had been previously cleared have been seeded, and the condition of the grass indicates a very satisfactory crop next season.

About one acre of land lying on either side of the road running between the Durfee pasture and the south flat has been improved by the removal of an enormous quantity of rubbish which had been deposited there while the place was used as a public dump, and by grading, plowing and seeding. This work greatly improves the appearance, and the land by the roadside will now yield a profitable crop of grass.

Considerable work in the way of improvement has also been done in the neighborhood of the rifle butt and in the ravine.

The Farm Finances.

The cash receipts for the year are $6,680.94, and there is due on accounts for sales made during the year the sum of $79.38; this, added to the cash receipts, makes a total of $6,760.32. Last year the similar total was $10,009.49; there is a decrease, therefore, for this year of $3,249.17. The total expenses of this year have amounted to $10,470.79. The inventory at the present time amounts to $17,912.58, which is $878.27 less than the inventory of last year. Although the machines, implements, vehicles, etc., of the farm have suffered the usual depreciation from use, the decrease in the inventory is the consequence mainly of a more discriminating valuation. The decrease is confined entirely to the items which make up the equipment of the farm. The cash received during the year has been derived from the following sources: for milk and cream, $3,125.50; cattle, including calves for veal, $1,385; horses, including fees for the use of stallions, $241.50; swine, $198.71; sheep, $120.27; hay, $86.61; potatoes, $445.66; celery, $122.46; team labor, $1,084.95; manual labor, $52.36; and sundries, $680.33.

WM. P. BROOKS,
Professor of Agriculture.

Amherst, Dec. 26, 1904.

MILITARY DEPARTMENT.

President H. H. Goodell, *Massachusetts Agricultural College.*

Sir: — I have the honor to submit the following report of the military department of this college for the year ending Dec. 31, 1904.

Instruction has been both practical and theoretical, conducted in compliance with the college schedule and regulations.

Under the provisions of General Orders, No. 65, War Department, dated April 6, 1904, educational institutions at which regular army officers are detailed for duty are divided into three classes, designated A, B and C, and the course of military instruction prescribed for each. Under the provisions of the above-mentioned order this college is placed in Class B, and the following course of instruction prescribed, viz.: —

Practical. — Infantry drill regulations through the school of the battalion, in close and extended order; advance and rear guards, outposts and marches; the ceremonies of battalion parade, review, inspection and escort of the colors; infantry target practice; instruction in first aid to the injured; a guard to be mounted five times in each week of the school year, weather permitting, and the guard practically instructed for one hour in the posting and relief of sentinels and their duties, the latter to be outside the hours provided for other ceremonies.

Theoretical. — Infantry drill regulations covered by practica instruction; the manual of guard duty; small arms firing regulations, and the most important of the articles of war; records which pertain to the administration of a company; ten lectures during the course of each school year on various military subjects, notes to be taken by the students, and made the basis of subsequent recitations.

This order has been complied with as far as it pertains to theoretical instruction, but only with the senior and freshman classes, as per college schedule. The order relating to practical instruc-

tion has been complied with only as provided by college schedule, — three hours per week, as scheduled, with the addition of certain exercises from 8.30 to 10.30 A.M. every Saturday, instituted to satisfy demerits incurred in the military department, such as unauthorized absence from drill or inspection, or rooms, arms and equipments or uniform not in proper condition.

The hours of regular drill are from 3.45 to 4.45 P.M., every Monday, Tuesday and Thursday. All rooms occupied by students in dormitories, all closets, sinks, etc., are carefully inspected every Saturday morning, and special attention paid to sanitation. Students not otherwise engaged are required to be present at these inspections. The order of drill commences with small squads for freshmen, and continues until they are sufficiently instructed for assignment to companies, after which the exercises include all drills and ceremonies prescribed for company and battalion. On account of the inclemency of the weather during the winter, all drills and ceremonies are conducted in the drill hall, and, in order to avoid tedious monotony, embrace infantry manual of arms; field artillery, single gun detachment only; gallery practice, consisting of firing at an iron target with the service rifle and reduced charge of powder; sighting and aiming drill; Butt's "Manual of Physi cal Drill;" first aid to the injured; and signal drill.

Most of the students have had target practice during the past year, at short ranges, with the old Springfield cadet rifle. The results obtained have not been entirely satisfactory, owing to the limited time at my disposal. A student who is given an opportunity to practice on the range only a few times during the whole year, and these times limited to the drill hour, cannot be expected to manifest much enthusiasm. This is a subject which is given great weight in all military organizations, both regular and militia, and should receive greater consideration in this college. To become a good marksman requires intelligent instruction on the range, a careful study of the mechanism of the rifle, and frequent practice under various conditions of weather. In all previous annual reports I have recommended that the student body be allowed to go into camp for one week in each college year, about the first week in May, and the time devoted to practical instruction in field service, such as guard and outpost duty, target practice, construction of shelter trenches and castrametation. I consider this of inestimable value to all military students, but have not yet been able to carry it out, from lack of the necessary camp and garrison equipage.

In theoretical instruction I have given more than the required lectures on the subjects prescribed. I have had recitations from the senior class every Monday, and from the freshman class every Monday, Tuesday and Thursday. On account of the large class and the inadequacy of the lecture room it has been divided into three sections, so that I am able to meet all of the class once each week.

I beg to repeat the recommendation made in my last annual report, that a physician be employed and paid by the State, to devote one or two hours each day attending upon any of the students who may require such service. In addition to the reasons assigned in this recommendation, it will also prevent the danger of spreading contagious disease. I respectfully invite special attention to this subject.

All the buildings under my supervision are in good condition except the drill hall, which is greatly in need of shingling. This recommendation has been made in previous reports, but it has been found impossible to carry it out. The plumbing in all the buildings appears to be in good sanitary condition.

By act of Congress of Jan. 21, 1903, every ablebodied male citizen of the United States, between the ages of eighteen and forty-five years, is made a member of the militia, which is divided into two classes, the organized and unorganized, the organized militia to be known as the National Guard, and the unorganized to be known as the Reserve Militia. The same act authorizes the President to call forth such militia, from one or both classes, whenever it becomes necessary to suppress rebellion, to repel invasion or to execute the laws of the United States. The primary object of military instruction in educational institutions is to fit young men to hold commissions in such forces whenever called out. It has also a tendency to inculcate the spirit of patriotism in college students, by making them realize that, as citizens of the country, they owe a duty to it which they are liable to be called upon to discharge in a position of honor and trust. The true spirit of patriotism should dominate all military instruction, for without it tactical education is of little or no value.

Under the provisions of General Orders No. 94, War Department, 1902, the following-named students of the class of 1904 were reported to the Adjutant-General of the Army and the Adjutant-General of the Commonwealth as having shown special aptitude in the military department, viz.: Fayette D. Couden, Howard M. White and Clarence H. Griffin.

The following is a list of ordnance and ordnance stores on hand, property of the United States, in possession of the college, viz. : —

2	3.2-inch breech-loading steel guns, with implements complete.
2	8-inch mortars, with mortar beds and implements.
2	carriages and limbers for 3.2 B. L. steel rifles.
147	Springfield cadet rifles, model 1884.
147	sets infantry accoutrements.
51	headless shell extractors.
1	set reloading tools.
6	non-commissioned officers' swords, steel scabbards.
14	non-commissioned officers' waist belts and plates.
50	blank cartridges for field guns.
4,000	metallic rifle ball cartridges, calibre 45.
4,500	metallic blank cartridges, calibre 45.
250	friction primers, radial, for field guns.
10,000	cartridge primers, small arms.
4,000	round balls for gallery practice.
25	pounds of powder, small arms, reloading.
8,000	pasters, black and white.
150	paper targets, "A" and "B."
1	set of marking rods, disks and brushes for gallery practice.

All this property is in good condition and well cared for. The Springfield cadet rifles are old and obsolete. It is very desirable to exchange them for the more modern rifle as soon as it can be done. I am informed, however, that this cannot be done until all the troops of the regular army and national guard have been supplied. It might be possible to obtain the "Krag Jorgensen" rifle, which is a great improvement over the old ones we now have; but this has recently been discarded by the regular army, and the improved Springfield, magazine rifle, calibre 30, adopted in its place, hence the "Krag Jorgensen" is now obsolete. It will, no doubt, be a long time before the new Springfield will be issued to colleges.

The military organization at present is as follows: one battalion of two companies of infantry, staff and band. For the purpose of battalion drill and ceremonies the two companies are equalized into four.

Commandant.

JOHN ANDERSON, ... Major, U. S. Army, Retired.

Staff and Non-commissioned Staff.

Cadet Adjutant, ... First Lieut. EDWIN W. NEWHALL, Jr.
Cadet Quartermaster, . . . First Lieut FRANCIS A. BARTLETT.
Cadet Sergeant-Major, ... EDWARD T. LADD.
Ordnance Sergeant, ... JOHN J. GARDNER.
Priv. HUGH L. BARNES, battalion clerk.

Band.

CHARLES S. HOLCOMB, Chief musician, with rank of first lieutenant.
PERCY F. WILLIAMS, . Principal musician, with rank of first sergeant.
LEWELL S. WALKER, ... Sergeant.
LOUIS H. MOSELEY, ... Corporal.
STANLEY S. ROGERS, ... Corporal.
Privates, 14; aggregate, 19.

Company A.

FREDERICK L. YEAW, ... Cadet Captain.
GRENVILLE N. WILLIS, ... Cadet First Lieutenant.
JOHN F. LYMAN, ... Cadet Second Lieutenant.
GEORGE W. PATCH, ... Cadet First Sergeant.
WALTER B. HATCH, ... Cadet Sergeant.
BERTRAM TUPPER, ... Cadet Sergeant.
CLARENCE W. LEWIS, ... Cadet Sergeant.
NORMAN D. INGHAM, ... Cadet Sergeant.
WILLIAM M. SEARS, ... Cadet Corporal.
ARTHUR W. HALL, Jr., ... Cadet Corporal.
HERMAN A. SUHLKE, ... Cadet Corporal.
FRY C. PRAY, ... Cadet Corporal.
WALTER E. DICKINSON, ... Cadet Corporal.
WILLIAM W. COLTON, ... Cadet Corporal.
BENJAMIN STRAIN, ... Cadet Corporal.

Total, Company A, 3 officers, 5 sergeants, 7 corporals, 54 privates; aggregate, 69.

Company B.

GEORGE H. ALLEN, ... Cadet Captain.
WILLARD A. MUNSON, ... Cadet First Lieutenant.
ALBERT D. TAYLOR, ... Cadet Second Lieutenant.
CHESTER L. WHITAKER, ... Cadet First Sergeant.
THOMAS F. HUNT, ... Cadet Sergeant.
JAMES R. KELTON, ... Cadet Sergeant.
RICHARD L. ADAMS, ... Cadet Sergeant.
HARVEY D. CROSBY, ... Cadet Sergeant.
DANIEL H. CAREY, ... Cadet Corporal.
JAMES E. MARTIN, ... Cadet Corporal.

Frederick C. Peters,	Cadet Corporal.
George T. French,	Cadet Corporal.
Charles A. Tirrell,	Cadet Corporal.
Ralph W. Peakes,	Cadet Corporal.
Alexander H. M. Wood,	Cadet Corporal.

Total, Company B, 3 officers, 5 sergeants, 7 corporals, 55 privates; aggregate, 70.

Total in military department: 2 captains, 7 lieutenants, 14 sergeants, 16 corporals, 124 privates; aggregate, 163. Aggregate in military department last year, 139, — a net increase of 24.

Respectfully submitted,

JOHN ANDERSON,

Major, U. S. Army, Retired, Commandant.

Report of the President of the Massachusetts Agricultural College to the Secretary of Agriculture and the Secretary of the Interior, as required by Act of Congress of Aug. 30, 1890, in Aid of Colleges of Agriculture and the Mechanic Arts.

I. Receipts for and during the Year ended June 30, 1904.

1. State aid: —	
(*a*) Income from endowment,	$1,919 19
(*b*) Appropriation for current expenses,	21,000 00
2 Federal aid: —	
(*a*) Income from land grant, act of July 2, 1862,	3,650 00
(*b*) Additional endowment, act of Aug. 30, 1890,	16,666 66
(*c*) For experiment stations, act of March 2, 1887,	15,000 00
3. Fees and all other sources,	3,292 00
Total,	$61,527 85

II. Property, Year ended June 30, 1904.

Value of buildings,	$248,775 00
Value of other equipment,	184,243 35
Total number of acres,	404
Acres under cultivation,	275
Acres used for experiments,	60
Value of farm and grounds,	$44,350 00
Number of acres of land allotted to State under act of July 2, 1862,	360,000
Amount of land grant fund of July 2, 1862,	$219,000 00
Amount of other permanent funds,	141,575 35
Number of bound volumes in library June 30, 1904,	25,268

III. Faculty during the Year ended June 30, 1904.

1. College of Agriculture and Mechanic Arts, collegiate and special classes,	26
2. Number of staff of experiment station,	22

IV. Students during the Year ended June 30, 1904.

1. College of Agriculture and Mechanic Arts, collegiate and special courses,	213
2. Graduate courses,	7
Total, counting none twice,	220

SEVENTEENTH ANNUAL REPORT

OF THE

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE.

JANUARY, 1905.

HATCH EXPERIMENT STATION

OF THE

MASSACHUSETTS AGRICULTURAL COLLEGE,

AMHERST, MASS.

OFFICERS.

HENRY H. GOODELL, LL.D.,	*Director.*
WILLIAM P. BROOKS, PH.D.,	*Agriculturist.*
GEORGE E. STONE, PH.D.,	*Botanist.*
CHARLES A. GOESSMANN, PH.D., LL.D.,	*Chemist* (fertilizers).
JOSEPH B. LINDSEY, PH.D.,	*Chemist* (foods and feeding).
CHARLES H. FERNALD, PH.D.,	*Entomologist.*
FRANK A. WAUGH, M.S.,	*Horticulturist.*
J. E. OSTRANDER, C.E.,	*Meteorologist.*
HENRY T. FERNALD, PH.D.,	*Associate Entomologist.*
FREDERICK R. CHURCH, B.SC.,	*Assistant Agriculturist.*
NEIL F. MONAHAN, B.SC.,	*Assistant Botanist.*
HENRI D. HASKINS, B.SC.,	*First Assistant Chemist* (fertilizers).
EDWARD G. PROULX, B.SC.,	*Second Assistant Chemist* (fertilizers).
EDWARD B. HOLLAND, M.S.,	*First Chemist* (foods and feeding).
PHILIP H. SMITH, B.SC.,	*Assistant Chemist* (foods and feeding).
ERWIN S. FULTON, B.SC.,	*Assistant Chemist* (foods and feeding).
ALBERT PARSONS, B.SC.,	*Inspector* (foods and feeding).
SUMNER R. PARKER, B.SC.,	*Dairy Tester* (foods and feeding).
JOSEPH G. COOK, B.SC.,	*Assistant in Foods and Feeding.*
GEORGE O. GREENE, M.S.,	*Assistant Horticulturist.*
GEORGE W. PATCH,	*Observer.*

The co-operation and assistance of farmers, fruit-growers, horticulturists and all interested, directly or indirectly, in agriculture, are earnestly requested. Communications may be addressed to the "Hatch Experiment Station, Amherst, Mass."

The following bulletins and reports are still in stock, and can be furnished on demand: —

No. 27. Tuberculosis in college herd; tuberculin in diagnosis; bovine rabies; poisoning by nitrate of soda.
No. 33. Glossary of fodder terms.
No. 35. Agricultural value of bone meal.
No. 41. On the use of tuberculin (translated from Dr. Bang).
No. 57. Fertilizer analyses.
No. 64. Analyses of concentrated feed stuffs.

No. 67. Grass thrips; treatment for thrips in greenhouses.
No. 68. Fertilizer analyses.
No. 75. Fertilizer analyses.
No. 76. The imported elm-leaf beetle.
No. 77. Fertilizer analyses.
No. 79. Growing China asters.
No. 81. Fertilizer analyses; treatment of barnyard manure with absorbents; trade values of fertilizing ingredients.
No. 82. Orchard management; cover crops in orchards; pruning of orchards; report on fruits.
No. 83. Fertilizer analyses.
No. 84. Fertilizer analyses.
No. 86. Orchard treatment for the San José scale.
No. 87. Cucumbers under glass.
No. 89. Fertilizer analyses; ash analyses of plants; instructions regarding sampling of materials to be forwarded for analysis.
No. 90. Fertilizer analyses.
No. 91. Injuries to shade trees from electricity.
No. 92. Fertilizer analyses.
No. 93. Concentrated feeds.
No. 95. Fertilizer analyses; notes on barnyard manure; trade values of fertilizing ingredients.
No. 96. Fungicides; insecticides; spraying calendar.
No. 97. A farm wood lot.
No. 98. Inspection of concentrates.
No. 99. Dried molasses beet pulp; the nutrition of horses.
No. 100. Fertilizer analyses; market values of fertilizing ingredients.
No. 101. Inspection of concentrates.
Special bulletin, — The coccid genera Chionaspis and Hemichionaspis.
Technical bulletin, No. 1, — Greenhouse Aleyrodes; strawberry Aleyrodes.
Technical bulletin, No. 2, — The graft union.
Index, 1888–95.
Annual reports for 1897, 1898, 1899, 1900, 1901, 1902, 1903, 1904.

Of the other bulletins, a few copies remain, which can be supplied only to complete sets for libraries.

ANNUAL REPORT

OF GEORGE F. MILLS, *Treasurer* OF THE HATCH EXPERIMENT STATION OF MASSACHUSETTS AGRICULTURAL COLLEGE,

For the Year ending June 30, 1904.

Cash received from United States Treasurer, . . .		$15,000 00
Cash paid for salaries, ...	$6,012 05	
for labor, ...	3,070 03	
for publications, ...	1,017 89	
for postage and stationery, . .	297 42	
for freight and express, . .	116 30	
for heat, light, water and power,	477 95	
for chemical supplies, . . .	25 40	
for seeds, plants and sundry supplies,	408 19	
for fertilizers, ...	1,331 20	
for feeding stuffs, . . .	401 28	
for library, ...	31 70	
for tools, implements and machinery,	221 33	
for furniture and fixtures, . .	509 31	
for scientific apparatus, . .	318 21	
for live stock, ...	313 50	
for travelling expenses, . .	137 02	
for contingent expenses, . .	10 00	
for building and repairs, . .	301 22	
		$15,000 00
Cash received from State Treasurer, . .	$13,000 00	
from fertilizer fees, . .	4,204 58	
from farm products, . .	2,714 79	
from miscellaneous sources, .	3,606 92	
Balance June 30, 1903, ...	3,198 56	
		$26,724 85
Cash paid for salaries, ...	$13,134 20	
for labor, ...	1,985 23	
Amount carried forward, . . .	$15,119 43	

Amount brought forward, . . .	$15,119 43	
Cash paid for publications, ...	1,415 18	
for postage and stationery, . .	551 11	
for freight and express, . .	161 96	
for heat, light, water and power,	405 88	
for chemical supplies, . . .	450 71	
for seeds, plants and sundry supplies,	321 52	
for fertilizers, ...	3 70	
for feeding stuffs, . . .	840 60	
for library, ...	215 80	
for tools, implements and machinery,	100 34	
for furniture and fixtures, . .	340 15	
for scientific apparatus, . .	952 56	
for live stock, ...	375 75	
for travelling expenses, . .	1,757 08	
for buildings and repairs, . .	329 53	
Balance, ...	3,383 55	
		$26,724 85

I, Charles A. Gleason, duly appointed auditor of the corporation, do hereby certify that I have examined the accounts of the Hatch Experiment Station of the Massachusetts Agricultural College for the fiscal year ended June 30, 1904; that I have found the same well kept and classified as above; that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000; for all of which proper vouchers are on file and have been by me examined and found correct, thus leaving no balance of the $15,000; and that $3,383.55 are left of the State appropriation and of funds received from miscellaneous sources.

CHARLES A. GLEASON,
Auditor.

Amherst, Aug. 15, 1904.

REPORT OF THE BOTANIST.

G. E. STONE, N. F. MONAHAN, ASSISTANT.

With the exception of a continual increase in our correspondence, the same routine has been pursued as in previous years. Experiments have been carried on in the greenhouse as usual on problems connected with roses, carnations, tomatoes, melons and violets. There are obscure diseases connected with these crops, which are in need of further study in order to throw more light on some practical methods of controlling or eliminating them.

Work has been continued on the effects of illuminating gas on trees, — a subject which is becoming important to communities. This matter is receiving attention in various States, on account of the not infrequent destruction of avenues of valuable shade trees. Experiments of various kinds pertaining to electricity and plant life in general have also received some attention. There is an increased interest in this subject, more particularly relating to the injurious effects which are too frequently manifested in valuable shade trees coming in contact with live wires. The department has also given considerable attention to the study of soil organisms, but this work at present is merely in a preliminary stage.

Crops as related to Weather Conditions.

Every season is distinctly peculiar as regards the prevalence or non-prevalence of specific fungous growths. The early potato blight appeared in most places to do more injury than usual during the early part of the summer. This is true even where crops were sprayed. As far as this season's results are concerned, it would indicate that spraying was not commenced early enough for controlling this blight.

Most potatoes ought to have been sprayed as early as June 12 or 15, in order to check the blight, or, in other words, when they were less than one-third grown. In regard to the mildew and wet rot on the potatoes, the effects were severe in some localities, and much loss was experienced.

The asparagus rust was more pronounced than last season. A stem rot caused much damage to cultivated dandelions, — a trouble which appears to be an unusual one in this State. Cucumber and melon blight have been exceedingly rare the past summer, being the first for about six years when no trouble has been experienced. The downy mildew (*Plasmopara Cubensis*, (B. and C.) Humphrey) of cucumbers and melons, which is believed to work its way north from the south each year, did not meet our attention once during the season. On the other hand, Alternaria and Anthracnose have existed here and there, but did no appreciable harm.

The worst injuries were due to winter-killing. In our last report we alluded briefly to disastrous effects of winter-killing of various shrubs and plants, caused by the unusual prolonged fall of 1902, and the severe and sudden cold occurring in December of that year. The winter of 1903 and 1904 was even more severe than the preceding one in causing injury to plants, and this injury showed itself in a different manner. Last winter was particularly characterized as causing severe injury to native plants, as well as exotic ornamentals. The effect of the extreme cold on plants was, moreover, quite different in the winter preceding, inasmuch as in 1902 and 1903 freezing of the tender wood above ground largely took place, while the effects of last winter's freeze extended both above and below the surface of the ground. The most characteristic feature of the last winter-killing was the injury done to the roots. This was particularly noticeable on apple, pear and plum trees, and the white pine suffered to a considerable extent in some localities. Many ornamental shrubs and vines also show the same characteristic effects of root killing. Numerous apple trees were killed outright, and thousands lost a greater or less number of limbs, due to an inadequate root system to supply them. Pear trees did not seem to be affected so extensively

as the apple. We observed pear trees which had their trunks split open two or three inches by the frost. The crevices eventually closed and commenced to heal over in the spring, although the effects of partial root killing have left many of them in a bad condition. The splitting of the stem is what is termed sun scald or frost crack, and the frost and sun are believed to be responsible for it. One of the characteristic results of partial root killing is that the trees will bear leaves in the spring and appear normal for a while, when suddenly the leaves commence to turn yellow and brown, and finally dry up and drop off. If only part of the root system is injured, the effects will show only on one or more branches or limbs; but when a large portion of the root system is involved, the whole tree is likely to collapse. The development of the leaves of many apple trees, and in some instances of peach and plum trees which had partially leaved out, was suddenly arrested, and they remained in this condition all summer.

White pines in some localities appeared to be injured extensively by cold, and such native species as the white ash, red and sugar maples, birches and poplars showed the effects of the severe winter. The red maples exhibited in many cases a scarcity of foliage, especially near the top; and more dead wood than usual was observed in some of the other species noted. The effects of root killing show more conspicuously when the soil moisture becomes reduced, and in many cases not until the season had become quite advanced did some trees show the effects of winter-killing. The effects on exotic plants were more severe than in 1902, since, in addition to the part above ground, the roots were injured.

Japanese maples, Japanese clematis, California privet, deutzia, roses, barberries, viburnums, etc., suffered to a considerable extent, and many were killed outright. This list could be greatly extended, and if complete would far exceed that noted in our last report. Sycamore and Norway maples have suffered from the loss of new wood during the past two years, as shown by the death of terminal branches. Grape vine roots were affected in many cases, and in some instances the maturing fruit wilted and dried up as if affected by the black rot.

On the whole, the season can be characterized as showing an unusual amount of winter-killing; in fact, more than has been seen for many years in this State.

Testing of Seed.

This department has frequently been called upon to do more or less of this work for farmers, and in many instances for seedsmen. Practically all seedsmen test their own seed; when, however, there is some doubt as to the germinating capacity, it occasionally becomes necessary to submit the seeds to a third party for results; in such cases the station is called upon to make tests. During the past year 120 samples have been tested for farmers and seedsmen.

The Practice of Soil Sterilization.

The application of steam under more or less high pressure to greenhouse soils contaminated with sterile fungi, and the use of hot water for partial sterilization, have been practised for a few years by greenhouse growers. We have had considerable experience with growing crops in sterilized soil, and some greenhouse growers have annually resorted to this method of treatment. It is our purpose to give a résumé of the results obtained from this practice.

Sterilization has been the means of lessening the amount of infection in lettuce houses in plants affected with drop and Rhizoctonia, and also of ridding houses of eel worms. It has also been the means of greatly stimulating the growth of crops; and in this respect it is likely to do as much harm as good, when intelligent supervision is not given to the crop. Some greenhouse men have resorted to sterilization for no other purpose than merely to try it, their houses being free from any infection for which this method of treatment could be recommended; while others have followed the practice of sterilizing for the purpose of modifying the growth and texture of their plants.

Besides the desired effect upon the eradication of drop and Rhizoctonia in lettuce houses, it has been the means of modifying to a large extent the texture of lettuce, and it has been employed as a stimulator. It has also been suc-

cessful in eradicating troublesome insect pests. Its principal drawbacks, however, in growing lettuce, have been due to its stimulating effects on the plant itself, which, where proper precautions are not taken as regards temperature, etc., result in developing a more tender plant, with a loose and less desirable head. A lettuce plant of this type is more tender because it contains more water, and it is not so desirable for the market. Moreover, such plants are inclined to be susceptible to Botrytis rot, if not properly handled. We learned very early in our experiments that, on account of the stimulating effect brought about by growing plants in sterilized soils, it is necessary to hold the crop back by maintaining lower night temperatures. If a temperature of from 8° to 10° F. lower than is customary at night is maintained, so that the crop may develop no faster than one grown under normal conditions, the result will be a crop possessing firm heads of equal texture and resisting qualities to that grown under normal conditions. We have repeatedly called attention to the necessity of this practice in growing lettuce in sterilized soils, but this advice has not always been followed.

There has been a slight increased tendency for lettuce plants to become more subject to Botrytis rot when grown in either sterilized soil or that treated by hot water, owing to a more accelerated growth, and the production of a head of less firm texture. Botrytis rot is the principal disease that most lettuce crops are troubled with at the present time. However, it is not a very serious one with good growers. There will be observed here and there a plant affected with Botrytis rot in the best of houses; the ideal conditions, however, require that there should be none. As to the loss by Botrytis rot by experienced growers, it is of no practical importance, since the percentage will be represented by a small decimal. Botrytis rot can, nevertheless, be eliminated to a greater extent than it is, if lettuce growers would follow certain precautions more carefully. In growing plants in sterilized soil, Botrytis rot can be reduced by paying attention to proper temperature conditions at night, or, in other words, by holding the crop within legitimate

limits. The principal sources of Botrytis infection are inferior prickers or seedlings. All prickers showing the black root should be discarded, as this is the beginning of the Botrytis rot. No prickers showing any injuries to the leaves, roots or cotyledons should be utilized, nor should any dead leaves be allowed to form on the plants or be left on them after transplanting. A strict adherence to the above precautions will greatly reduce Botrytis rot.

Another feature which should be considered in connection with the Botrytis rot, as well as rots in general, is watering. Lettuce growers have developed the tendency to do less watering after the crop is set than formerly. They apply most of the water previous to planting, at the present time. This practice induces the plant to develop a better root system. The surface of the soil becomes dry and remains so, which constitutes a great feature in eliminating Botrytis rot, drop, etc. Were it possible for air and sun to obtain access to a lettuce stem, there would scarcely be known such a thing as lettuce rot, with the present skill developed in handling this crop. Some growers have practised for some time the method of thoroughly wetting the soil before planting, and not applying any water after transplanting; while others water occasionally for only two or three weeks after transplanting. We demonstrated quite early in our work the importance of keeping the surface of the soil dry. Subirrigation methods reduce the rots to a considerable extent; and the method of thoroughly wetting the soil previous to planting, and not supplying any water afterwards, is similar in its effects to subirrigation, besides having the advantage of being a much cheaper method. Top coatings of clean, dry sand and other substances have similar effects in reducing rots.

We believe that a great deal can be accomplished in eliminating Botrytis rot and other diseases if more care be taken in selecting seed of a more uniform size and character. Care should be taken in selecting seed that will produce more hardy plants, and that which will produce plants less subject to infection. There is a chance for experimentation and more careful study here.

In one instance we have heard it implied that lettuce

crops grown in sterilized soil were prone to mildew. This may result to some extent when the crop is not properly handled; but mildew is confined to the houses of only a very few commercial growers, and its existence in a house at all can be accounted for otherwise. We introduced the mildew into our house several times, but it always died out, and was never known to live through the summer. On the whole, far better lettuce crops are turned out to-day than five years ago, and there is a decided decrease in the amount of infection, due to the application of improved methods of treatment and culture.

As regards the effects of sterilized soil on the growth of cucumbers, our experiments and those of others have shown favorable results, since cucumbers will stand a considerable amount of forcing without any detriment; and we have none of the drawbacks due to excessive stimulation of the crop, such as we find in lettuce. When cucumbers are grown under single lights of glass, or under favorable conditions as regards light, the stimulating effects due to sterilization act most advantageously; while, on the other hand, where the crop is grown under exceedingly abnormal conditions as regards heat, light and moisture, as it sometimes is, no appreciable results are noticeable, except in so far as the treatment eliminates undesirable pests from the soil. Indeed, no form of stimulation is of any practical value to plants when their conditions of growth are extremely abnormal. Sterilization is especially efficacious in destroying eel worms and preventing timber rot, and also destroys some insect pests which trouble the cucumber. One of the special advantages in growing cucumbers in sterilized soil is connected with the seed and seedling, since germination of the seeds is hastened, the plants are accelerated, and damping-off is prevented. A considerable amount of acceleration is given to the growth of the seedling; and in our experiments, where seeds were sown in sterilized and unsterilized soil, we obtained an increase in the actual germination of the seed equal to 33 per cent. in favor of sterilized soil. The expense of sowing seeds and starting seedlings in sterilized soil would be slight, and the results obtained render this process especially desirable.

The growing of carnations in sterilized soil, according to our limited experiments, shows a slightly beneficial effect on the plant, although others who have had more extensive experience have noted very little difference as the result of this practice. It is especially applicable to carnations in eliminating the wet stem rot caused by the fungus Rhizoctonia. In our opinion, there is little reason to believe that sterilizing would succeed in preventing the dry rot caused by Fusarium. With carnations, soil sterilization possesses some advantage in the cutting bed where cuttings are affected with Rhizoctonia and the damping-off fungus (*Pythium De Baryanum*, Hesse). In our rather extensive use of sterilized soil we have never observed any detrimental influence on the soil itself; we have, however, always made use of a tolerably rich soil, well supplied with organic matter.

The principal forms of appliances now used for this purpose are similar, with some modifications, to those which have been employed for five or six years. Perforated iron pipes made up into frames, 10 to 12 feet long and 8 to 10 feet wide, are most generally used. The harrow form of apparatus, known as the Sargent sterilizer, is also largely used, and consists of an iron frame, 4 or 5 by 8 or 10 feet, provided with perforated teeth about 10 or 12 inches apart and 1 foot long. The teeth are thrust into the soil, and the steam is turned on. With this form of apparatus it is not necessary to shovel the soil, hence the process is cheap. The latter type requires a high pressure of steam, and not so great a volume; while the former apparatus requires a large volume of steam, and can be operated to advantage with 15 or 20 pounds of steam pressure.

The Influence of Electrical Potential on the Growth of Plants.[1]

In our last report we gave results of experiments showing the effects of current electricity upon the growth of plants, also the results of subjecting plants and moist seeds to different electrical potentials. We shall give here the results

[1] These experiments were conducted by N. F. Monahan.

of further experiments along similar lines, and present some results relating to differences of electrical potential which exist between locations in trees and corresponding situations more or less removed from them.

In the first series of experiments we will consider the influence of electrical potential upon growth. In subjecting plants to an atmospheric charge of a certain potential we used a glass case such as is described in our preceding report, being, briefly, a glass case 3 feet 4 inches long, 2 feet 9 inches wide and 2 feet 11 inches high, with shellacked wooden frames and bottom. Another case, for comparison, and similar in structure but slightly larger, was also employed. Both cases were tolerably tight when closed, and were placed on movable trucks, from which they were well insulated, in a large greenhouse. The greenhouse screened out, as it were, the atmospheric electricity. At no time have we ever been able to detect any electrical potential in the air in greenhouses. The soil used in growing the plants was of uniform type, very carefully mixed; in fact, every precaution was taken to have the soil conditions the same in each case, and all its various constituents were thoroughly incorporated.

In the case which was to be treated was placed a small water-dripping apparatus, which served as a collector, and which indicated the degree of charging. The air was charged by means of a wire projecting into the case from a Topler-Holtz influence machine. All electrical readings were measured by a Thompson quadrant electrometer.

In the two experiments now described radish plants were employed, as they seemed to be most suitable for the condition under which they were grown. The seeds were of a uniform grade, and were sown in rows 3 inches apart and 1 inch apart in the rows. It was the intention to charge the case each morning to a potential of 150 volts; but this was impossible, as exactly 150 volts could not always be obtained, and at times, on account of the dampness of the air, no charge could be procured from the machine. The doors of both cases were kept closed for four hours after the charge had been induced into the treated case, and at the end of that time they were opened; therefore, for twenty out of every

twenty-four hours all the plants were growing under the same conditions. At all times the conditions of temperature and moisture were practically the same in both charged and normal, or uncharged, cases.

TABLE I., EXPERIMENT I. (*Raphanus sativus* L.). — *Showing the Results obtained by electrically charging the Air in a Case.*

CASE.	Average Daily Charge (Volts).	Number of Plants.	TOTAL WEIGHT IN GRAMS OF —	
			Tops.	Roots.
Normal case, ...	-	219	2,211.3	510.3
Electrically charged case, .	167.2	162	2,551.5	623.7

TABLE I., EXPERIMENT I. (*Raphanus sativus* L.). — *Showing the Results obtained by electrically charging the Air in a Case* — Concluded.

CASE.	AVERAGE WEIGHT IN GRAMS OF —		PER CENT. GAINED IN WEIGHT OF —		Total Per Cent. gained.
	Tops.	Roots.	Tops.	Roots.	
Normal case, ...	10.097	2.333	-	-	-
Electrically charged case,	15.750	3.850	55.98	65.67	57.67

The experiment in Table II. is similar to Experiment I., except that the seeds were planted in rows 5 inches apart, instead of 4, as in the preceding one. The cold weather interfered with the development of the plants, and the experiment was brought to a close earlier than was planned.

TABLE II., EXPERIMENT II. (*Raphanus sativus* L.). — *Showing the Results obtained by electrically charging the Air in a Case.*

CASE.	Average Daily Charge (Volts).	Number of Plants.	TOTAL WEIGHT IN GRAMS OF —	
			Tops.	Roots.
Normal case, ...	-	136	91	98.5
Electrically charged case, .	141.2	69	66	74.0

TABLE II., EXPERIMENT II. (*Raphanus sativus* L.). — *Showing the Results obtained by electrically charging the Air in a Case* — Concluded.

CASE.	AVERAGE WEIGHT IN GRAMS OF—		PER CENT. GAINED IN WEIGHT OF—		Total Per Cent. gained.
	Tops.	Roots.	Tops.	Roots.	
Normal case, . . .	.669	.724	-	-	-
Electrically charged case,	.955	1.072	42.73	49.46	45.58

The results given in tables I. and II. are quite similar. In Table I. there was a gain of 55.98 per cent. in the weight of tops or leaves and 65.67 per cent. in the weight of roots, over the uncharged plants; in Table II., the percentage given for the tops is 42.73 and for the roots 49.46. The total gain in Experiment I. is 57.67 per cent.; in Experiment II. it is 45.58 per cent. The average gain in both experiments was 49.35 per cent. for the tops or leaves, 57.56 per cent. for the roots and 51.62 per cent. as an average total gain for the electrically stimulated plants. The charge in Experiment I. averaged 167.2 volts; in Experiment II., 141.2 volts. The charge only lasted a few seconds in all instances, and practically disappeared from the atmosphere of the case in fifteen minutes.

Some measurements were occasionally made of a dozen typical plants from each case in Experiment I. The object in taking these measurements was, first, to show the difference in size and degree of acceleration, differentiation, etc., of the treated and untreated plants; and, second, to compare the electrically treated plants with those that were not treated, when the latter were practically in the same stage of development; or, in other words, the plants in the electrically charged case were compared with those in the untreated case on the day in which the measurements were made, and also five days later, when the development of the normal plants had reached practically the same stage as that of the plants in the electrically treated case. By this method any changes in the external configuration of the plants brought about by electrical stimulation could be noted.

Table III. shows the results of these measurements, and Table IV. gives a comparison between the leaves of the plants in the charged and uncharged cases, measurements being made August 15 and August 20, respectively.

TABLE III. — *Showing the Average of Some Measurements of Plants in Table I., Experiment I.*

Date.	CASE.	Width of Leaf (Centimeters).	Length of Blade (Centimeters).	Length of Petiole (Centimeters).	Length of Whole Leaf (Centimeters).
August 15,	Normal case, . . .	2.13	4.17	2.28	6.49
	Electrically charged case, .	2.66	5.33	4.34	10.16
	Difference, . . .	.53	1.16	2.06	3.67
August 20,	Normal case, . . .	2.79	4.83	3.35	8.10
	Electrically charged case, .	3.65	6.95	5.20	12.05
	Difference, . . .	.86	2.12	1.85	3.95

TABLE IV. — *Giving a Comparison between the Leaves of the Plants in the Charged and Uncharged Cases.*

Date.	CASE.	Width of Leaf (Centimeters).	Length of Blade (Centimeters).	Length of Petiole (Centimeters).	Length of Whole Leaf (Centimeters).
August 20,	Normal case, . . .	2.79	4.83	3.35	8.10
August 15,	Electrically charged case,	2.66	5.33	4.34	10.16
	Difference, . . .	.13	.50	.99	2.06

The results of these experiments show what was readily discernible with the naked eye; namely, that the length of leaves of the electrically treated plants was quite different from those of the normal or untreated plants, and that the width and length of the leaf blade and the length of the petioles of the plants in the electrically treated case exceeded those of the normal or untreated plants. When comparisons, however, are made of the plants in the electrically treated case of August 15 with those of the normal of August 20, or five days later, it will be observed that the width of the blade of the normal exceeded that of the treated one by .13 centimeters, and that the difference in the length of the blades,

petioles and leaves in general was much less marked. The length of the blade, petiole and whole leaf in general was longer for identical periods of development in the electrically treated plants than in the normal or untreated, although the width of the blade was more generally marked in its development in the normal than in the plants in the electrically charged case. The morphological differentiation due to electrical stimulation is shown in these experiments.

The plants in the electrically charged case were of a lighter-green color, and they showed a greater tendency to leaf burn than did the normal plants. They also appeared to be more succulent, but moisture determinations made of the leaves at the close of the experiment showed no difference in this respect. The roots in the treated case were relatively more elongated than those in the untreated case. Whether this form of electrical treatment stimulates plants more than current electricity cannot definitely be determined, from the lack of a sufficient number of comparative results. However, these two experiments would indicate, both from naked-eye observations and from weights and measurements, that static charges act as more pronounced stimuli than current electricity when applied to soils. Electrical stimulation gives rise to effects similar to those caused by lack of light, or such as result from partial etiolation. The light-green color of the foliage and the elongated organs were similar to those noticed in plants grown in poorly lighted greenhouses in winter, and in shaded plants grown in the forest. Other kinds of electrical stimulation appear to have the same general effects on the plant.

Comparison of Atmospheric Electrical Potential in Trees and in the Free Air.

The idea has been advanced that trees, shrubs, and in fact all growing plants, must form a means by which the potential of the air and the earth is held in equilibrium. A living tree does not offer such an enormous resistance to the passage of electricity as dead wood does. We have charged small plants in the laboratory to a sufficiently high potential so that, when placed in the dark, sparks were emitted from

many points of the leaves, and living plants will readily take charges from a static machine. It has also been maintained that trees modify the electrical potential of the atmosphere of their immediate surroundings.

Grandeau[1] and other experimenters have shown that when plants are grown under wire netting they develop less in a given space of time than do plants grown under similar conditions in every respect as regards light, etc., in the free atmosphere. The interpretation of this phenomenon is, that wire screens modify the atmospheric electrical potential, or absorb the electricity, as it were, to the detriment of the plant. This method of experimenting with wire nets we have employed only to a limited extent, and at present have not a sufficient number of results on which to report. Unfortunately, most of the experiments previously made in this line are open to severe criticism, from the fact that too few plants were employed, and different methods of surrounding the plants with wire netting prevailed, which accounts for occasional conflicting results. Grandeau obtained similar results by growing plants under a chestnut tree, as under a wire netting; and he concluded that it is probable that trees modify to a large extent the electrical potential of the atmosphere in their immediate neighborhood. The object we had in view in these experiments was to ascertain, among other things, whether trees did modify in any way the electrical potential of the atmosphere in their immediate vicinity. In order to ascertain whether there is any discernible difference between the atmospheric electrical potential in trees and in the free air, at corresponding height and location, we made a series of three readings daily from April to July, and daily readings during the remainder of the experiment, with collectors and a Thompson quadrant electrometer. These observations were started early in the spring, before any foliage had developed, and continued until after the leaves had fallen. A collector was placed in an elm tree, at a height of 40 feet above the ground, at a fork between two limbs from which it was insulated. The collector was situated about on a level with, or slightly above, the spread of

[1] "Comptes rendus," T. LXXXVII., 1878, pp. 60, 285, 939. "Chimie et Physiologie appliquées a l'Agriculture et à la Sylviculture par L. Grandeau," Paris, 1879, p. 279.

the branches and leaves. The tree, however, was not in every respect a typical elm for this region, the head being high and close, with the branches drooping but little.

The collector in the tree is designated as II. in the following monthly records; and the one in the free air, which was located near a building, is designated as I. Collector III. was in a spruce tree, and Nos. IV. and V. were added in August. Collector III. was located 12 feet high, near the top and under the branches of a small Norway spruce. Nos. IV. and V. represent readings from two small Norway spruce trees, about 2 feet high, in pots; they were located about 16 feet from the ground, on a plank scaffold. No. IV. had a copper plate in the soil, which was connected with the electrometer when readings were made. No. V. had a similar plate, but was grounded with an insulated wire; another wire led from this copper plate in the soil to the electrometer.

Readings were taken from the various collectors on the same electrometer at practically the same time each day. Table V. shows readings taken from April 20 to Nov. 1, 1904, and where readings are omitted they could not be obtained. All readings not otherwise recorded imply negative potential.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air.*

DATE.	9 A.M.		1 P.M.		5 P.M.	
	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.
1904.						
April 21, . .	56.0	56.0	32.0	32.0	0.0	0.0
22, . .	48.0	48.0	32.0	32.0	16.0	16.0
23, . .	8.0	8.0	40.0	40.0	–	–
24, . .	16.0	16.0	16.0	16.0	16.0	–
25, . .	40.0	40.0	40.0	40.0	16.0	16.0
26, . .	32.0	32.0	16.0	16.0	32.0	32.0
27, . .	–	–	60.0	60.0	40.0	40.0
28, . .	8.0	8.0	32.0	32.0	45.0	45.0
29, . .	24.0	0.0	8.0	0.0	0.0	0.0
30, . .	32.0	32.0	–	–	–	–

April 24, trees show signs of budding.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Continued.

DATE.	9 A.M.		1 P.M.		5 P.M.	
	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.
1904.						
May 1, . .	112.0	112.0	32.0	32.0	0.0	0.0
2, . .	16.0	16.0	12.0	12.0	8.0	8.0
3, . .	48.0	48.0	40.0	40.0	48.0	48.0
4, . .	56.0	56.0	24.0	24.0	24.0	24.0
5, . .	56.0	56.0	56.0	56.0	8.0	0.0
6, . .	12.0	12.0	24.0	24.0	20.0	20.0
7, . .	64.0	64.0	28.0	24.5	–	–
8, . .	–	–	–	–	–	–
9, . .	–	–	–	–	–	–
10, . .	24.0	24.0	28.0	28.0	–	–
11, . .	48.0	48.0	8.0	8.0	16.0	16.0
12, . .	72.0	72.0	80.0	80.0	40.0	40.0
13, . .	64.0	64.0	8.0	0.0	24.0	20.0
14, . .	16.0	14.0	–	–	–	–
15, . .	8.0	0.0	8.0	0.0	–	–
16, . .	–	–	–	–	–	–
17, . .	–	–	32.0	–	–	–
18, . .	–	–	20.0	8.0	20.0	–
19, . .	40.0	32.0	32.0	17.0	16.0	12.0
20, . .	56.0	40.0	32.0	24.0	–	–
21, . .	8.0	0.0	16.0	9.0	20.0	16.0
22, . .	32.0	16.0	–	–	–	–
23, . .	8.0	4.0	16.0	8.0	32.0	24.0
24, . .	16.0	14.0	20.0	12.0	8.0	8.0
25, . .	218.0	32.0	16.0	16.0	20.0	16.0
26, . .	88.0	56.0	32.0	0.0	–	–
27, . .	–	–	–	–	–	–
28, . .	24.0	20.0	24.0	20.0	16.0	0.0
29, . .	32.0	0.0	28.0	0.0	–	–
30, . .	–	–	–	–	–	–
31, . .	–	–	–	–	–	–

May 7, leaves beginning to show; May 9, hardly a trace; May 14, trees fairly well leaved, seeds beginning to drop; heavy thunder showers on 26th; 5 P.M. readings gave extremely high and fluctuating potentials.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Continued.

DATE.	9 A.M.		1 P.M.		5 P.M.	
	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.
1904.						
June 1, . .	32.0	24.0	16.0	8.0	+8.0	−8.0
2, . .	–	–	–	–	–	–
3, . .	–	–	16.0	8.0	–	–
4, . .	–	–	16.0	8.0	–	–
5, . .	8.0	0.0	8.0	0.0	112.0	56.0
6, . .	20.0	0.0	8.0	0.0	0.0	0.0
7, . .	–	–	–	–	–	–
8, . .	–	–	–	–	–	–
9, . .	–	–	–	–	–	–
10, . .	–	–	16.0	8.0	8.0	0.0
11, . .	28.0	16.0	32.0	20.0	24.0	16.0
12, . .	72.0	56.0	8.0	0.0	8.0	0.0
13, . .	40.0	24.0	40.0	24.0	–	–
14, . .	8.0	0.0	32.0	0.0	–	–
15, . .	16.0	8.0	28.0	24.0	–	–
16, . .	8.0	0.0	8.0	0.0	–	–
17, . .	16.0	8.0	40.0	24.0	–	–
18, . .	36.0	24.0	28.0	20.0	16.0	0.0
19, . .	72.0	48.0	88.0	56.0	8.0	0.0
20, . .	32.0	20.0	16.0	8.0	8.0	0.0
21, . .	20.0	16.0	16.0	8.0	8.0	0.0
22, . .	20.0	8.0	–	–	–	–
23, . .	–	–	–	–	–	–
24, . .	–	–	–	–	–	–
25, . .	–	–	–	–	–	–
26, . .	–	–	–	–	–	–
27, . .	24.0	12.0	8.0	0.0	0.0	0.0
28, . .	16.0	12.0	8.0	trace	8.0	trace
29, . .	–	–	–	–	–	–
30, . .	–	–	–	–	–	–

June 2-4, rain; June 6-9, wet wire.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Continued.

DATE.	9 A.M.		1 P.M.		5 P.M.	
	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.
1904.						
July 1, . .	–	–	–	–	–	–
2, . .	–	–	–	–	8.0	4.0
3, . .	–	–	–	–	–	–
4, . .	–	–	–	–	–	–
5, . .	36.0	16.0	32.0	20.0	32.0	20.0
6, . .	28.0	12.0	24.0	0.0	24.0	0.0
7, . .	88.0	56.0	8.0	0.0	8.0	0.0
8, . .	–	–	20.0	8.0	28.0	12.0
9, . .	12.0	0.0	48.0	24.0	36.0	20.0
10, . .	–	–	–	–	8.0	0.0
11, . .	24.0	8.0	24.0	0.0	24.0	0.0
12, . .	–	–	–	–	–	–
13, . .	–	–	–	–	–	–
14, . .	–	–	–	–	–	–
15, . .	–	–	–	–	–	–
16, . .	–	–	–	–	–	–
17, . .	–	–	–	–	–	–
18, . .	–	–	–	–	–	–
19, . .	12.0	0.0	8.0	0.0	8.0	trace
20, . .	12.0	trace	16.0	4.0	16.0	4.0
21, . .	16.0	trace	28.0	8.0	12.0	trace
22, . .	–	–	–	–	–	–
23, . .	–	–	–	–	–	–
24, . .	–	–	–	–	–	–
25, . .	–	–	–	–	–	–
26, . .	–	–	–	–	–	–
27, . .	–	–	–	–	–	–
28, . .	20.0	8.0	24.0	8.0	–	–
29, . .	–	–	–	–	–	–
30, . .	28.0	8.0	32.0	16.0	16.0	trace
31, . .	–	–	–	–	–	–

July 12-18, electrometer out of order; July 22-28, rain.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Continued.

[Collector III., 12 feet high, in Norway spruce. Nos. IV. and V., readings taken from copper plates in soil. Time of observation, 9 A.M.]

DATE.	Collector I. — Free Air.	Collector II. — Elm.	Collector III. — Spruce.	No. IV. — Small Spruce Tree, not grounded.	No. V. — Small Spruce Tree, grounded.
1904.					
August 1, . .	88.0	52.0	–	–	–
2, . .	0.0	0.0	–	–	–
3, . .	8.0	0.0	–	–	–
4, . .	–	–	–	–	–
5, . .	–	–	–	–	–
6, . .	72.0	40.0	–	–	–
7, . .	32.0	16.0	–	–	–
8, . .	96.0	56.0	–	–	–
9, . .	40.0	24.0	–	–	–
10, . .	8.0	0.0	–	–	–
11, . .	16.0	8.0	Very	slight move	ment
12, . .	56.0	32.0	+4.0	+4.0	+4.0
13, . .	8.0	trace	+trace	+trace	+trace
14, . .	96.0	56.0	+6.0	+8.0	+16.0
15, . .	24.0	16.0	+trace	+4.0	+trace
16, . .	32.0	16.0	trace	+8.0	+12.0
17, . .	0.0	0.0	+8.0	+8.0	+12.0
18, . .	+16.0	+8.0	—8.0	—8.0	—8.0
19, . .	40.0	20.0	0.0	trace	trace
20, . .	–	–	–	–	–
21, . .	72.0	40.0	+8.0	+8.0	+12.0
22, . .	8.0	+trace	+trace	+trace	+trace
23, . .	8.0	trace	+8.0	+4.0	+8.0
24, . .	48.0	24.0	0.0	trace	trace
25, . .	56.0	28.0	0.0	0.0	trace
26, . . .	96.0	52.0	+8.0	+8.0	+12.0
27, . .	88.0	40.0	0.0	0.0	0.0
28, . .	40.0	24.0	0.0	0.0	0.0
29, . .	8.0	trace	0.0	0.0	0.0
30, . .	40.0	16.0	+2.0	+2.0	+2.0
31, . .	40.0	24.0	0.0	0.0	0.0

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Continued.

[Collector III., 12 feet high, in Norway spruce. Nos. IV. and V., readings taken from copper plates in soil. Time of observation, 3 P.M.]

DATE.	Collector I. — Free Air.	Collector II. — Elm.	Collector III. — Spruce.	No. IV. — Small Spruce Tree, not grounded.	No. V. — Small Spruce Tree, grounded.
1904.					
August 1, . .	80.0	40.0	–	–	–
2, . .	–	–	–	–	–
3, . .	8.0	0.0	–	–	–
4, . .	–	–	–	–	–
5, . .	–	–	–	–	–
6, . .	24.0	12.0	–	–	–
7, . .	40.0	24.0	–	–	–
8, . .	88.0	56.0	–	–	–
9, . .	24.0	12.0	–	–	–
10, . .	0.0	0.0	–	–	–
11, . .	8.0	0.0	0.0	0.0	0.0
12, . .	40.0	24.0	+4.0	+4.0	+4.0
13, . .	56.0	4.0	+trace	+trace	+trace
14, . .	24.0	12.0	+4.0	+trace	+4.0
15, . .	72.0	40.0	+4.0	+8.0	+12.0
16, . .	16.0	8.0	trace	trace	trace
17, . .	0.0	0.0	0.0	0.0	0.0
18, . .	0.0	0.0	0.0	0.0	0.0
19, . .	40.0	20.0	0.0	0.0	trace
20, . .	–	–	–	–	–
21, . .	40.0	24.0	+4.0	trace	12.0
22, . .	8.0	0.0	0.0	0.0	0.0
23, . .	8.0	0.0	+8.0	trace	trace
24, . .	56.0	32.0	0.0	0.0	0.0
25, . .	32.0	24.0	0.0	0.0	trace
26, . .	72.0	40.0	+8.0	+8.0	+8.0
27, . .	48.0	24.0	0.0	0.0	0.0
28, . .	8.0	trace	0.0	0.0	0.0
29, . .	4.0	0.0	0.0	0.0	0.0
30, . .	16.0	8.0	0.0	0.0	0.0
31, . .	40.0	24.0	0.0	0.0	0.0

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Continued.

[Collector III., 12 feet high, in Norway spruce. Nos. IV. and V., readings taken from copper plates in soil. Time of observation, 9 A.M.]

DATE.	Collector I. — Free Air.	Collector II. — Elm.	Collector III. — Spruce.	No. IV. — Small Spruce Tree, not grounded.	No. V. — Small Spruce Tree, grounded.
1904.					
September 1, .	88.0	52.0	+4.0	+4.0	+4.0
2, .	–	–	–	–	–
3, .	–	–	–	–	–
4, .	96.0	56.0	+8.0	+8.0	+8.0
5, .	72.0	40.0	4.0	2.0	4.0
6, .	—8.0	—trace	+0.0	+0.0	+0.0
7, .	40.0	24.0	0.0	0.0	0.0
8, .	56.0	32.0	0.0	0.0	0.0
9, .	72.0	40.0	0.0	trace	trace
10, .	–	–	–	–	–
11, .	–	–	–	–	–
12, .	–	–	–	–	–
13, .	–	–	–	–	–
14, .	–	–	–	–	–
15, .	–	–	–	–	–
16, .	–	–	–	–	–
17, .	–	–	–	–	–
18, .	–	–	–	–	–
19, .	–	–	–	–	–
20, .	–	–	–	–	–
21, .	–	–	–	–	–
22, .	–	–	–	–	–
23, .	–	–	–	–	–
24, .	–	–	–	–	–
25, .	–	–	–	–	–
26, .	0.0	0.0	0.0	0.0	0.0
27, .	8.0	8.0	0.0	0.0	trace
28, .	–	–	–	–	–
29, .	–	–	–	–	–
30, .	24.0	24.0	0.0	trace	trace

September 6, possibly slight movement toward positive in Nos. III., IV. and V.
Operator away from September 10 to September 25.

TABLE V. — *Records showing the Electrical Potential (Volts) taken from an Elm Tree and from Free Air* — Concluded.

[Collector III., 12 feet high, in Norway spruce. Nos. IV. and V., readings taken from copper plates in soil. Time of observation, 9 A.M.]

DATE.	Collector I. — Free Air.	Collector II. — Elm.	Collector III. — Spruce.	No. IV. — Small Spruce Tree, not grounded.	No. V. — Small Spruce Tree, grounded.
1904.					
October 1,	40.0	32.0	4.0	2.0	4.0
2,	56.0	48.0	4.0	trace	2.0
3,	96.0	80.0	8.0	trace	trace
4,	–	–	–	–	–
5,	8.0	8.0	4.0	4.0	8.0
6,	40.0	36.0	trace	trace	trace
7,	–	–	–	–	–
8,	–	–	–	–	–
9,	–	–	–	–	–
10,	–	–	–	–	–
11,	–	–	–	–	–
12,	–	–	–	–	–
13,	–	–	–	–	–
14,	8.0	8.0	2.0	2.0	4.0
15,	40.0	40.0	4.0	trace	4.0
16,	8.0	8.0	trace	0.0	0.0
17,	16.0	16.0	2.0	trace	2.0
18,	40.0	0.0	0.0	0.0	0.0
19,	24.0	24.0	trace	0.0	trace
20,	–	–	–	–	–
21,	–	–	–	–	–
22,	–	–	–	–	–
23,	–	–	–	–	–
24,	40.0	40.0	0.0	0.0	0.0
25,	8.0	8.0	trace	trace	trace
26,	–	–	–	–	–
27,	–	–	–	–	–
28,	–	–	–	–	–
29,	8.0	8.0	0.0	trace	trace
30,	–	–	–	–	–
31,	–	–	–	–	–

October 5, leaves turning color, very few falling; October 20, leaves taken off by high wind; October 24, leaves entirely off trees.

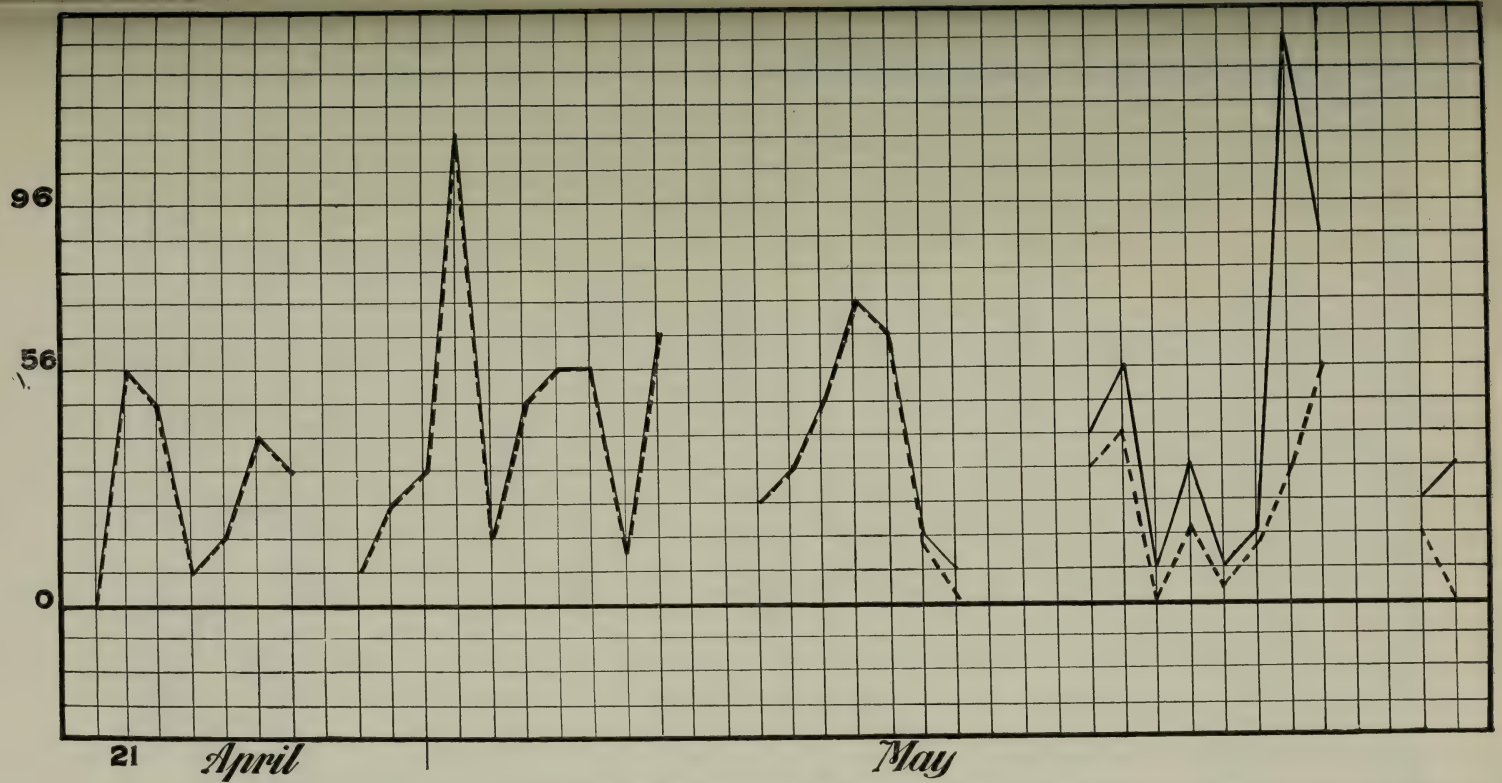

DIAGRAM I. — Showing the results of electrometer readings from free air, Collector I., and elm tree, Collector II., for the months of April and May. The spaces on the abscissa denote days; the spaces on the ordinate denote periods of eight volts each. Solid line indicates free air readings; dotted line indicates elm tree readings.

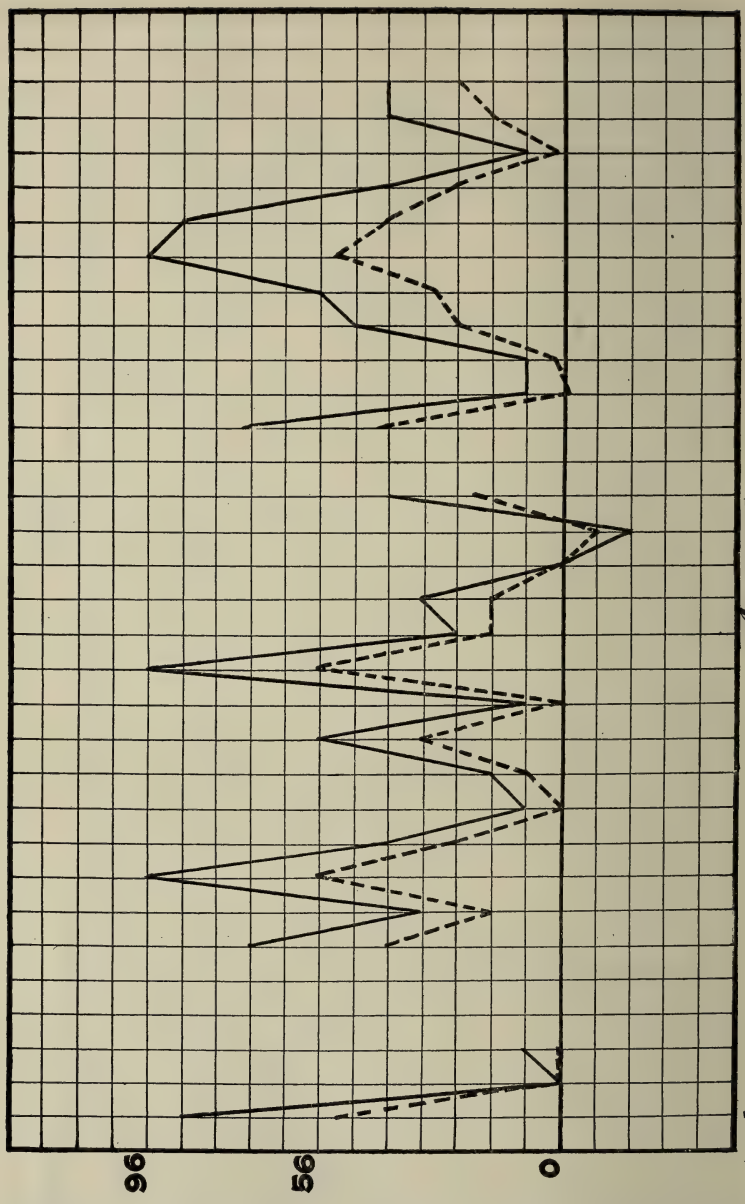

DIAGRAM II. — Showing the results of electrical readings from free air, Collector I., and elm tree, Collector II., for the month of August. The spaces on the abscissa denote days; the spaces on the ordinate denote periods of eight volts each. Solid line indicates free air readings; dotted line indicates elm tree readings.

TABLE VI. — *Summary of Potential Readings of the Preceding Tables, showing the Total and Average Results given by Collector I. (Free Air) and Collector II. (Elm Tree).*

	Total Voltage of—		Average Daily Voltage of—	
	Collector I. — Free Air.	Collector II. — Elm.	Collector I. — Free Air.	Collector II. — Elm.
April,	240	240	30.0	30.0
May 1 to May 14,	572	572	52.0	52.0
May 14 to May 31,	398	228	44.2	25.3
June,	498	276	38.0	21.2
July,	224	108	37.3	18.0
August,	1,088	592	54.4	29.6
September,	456	276	57.0	34.5
October 1 to October 7,	240	204	48.0	40.8
October 7 to October 31,	152	152	19.0	19.0

While the results obtained from this series of experiments do not possess the same value as the series extending over more than one season, they nevertheless point very strongly to the conclusion that trees do modify to a considerable extent atmospheric electrical potential in their immediate vicinity. By consulting the summary, Table VI., where the total and average potentials for different periods are shown, it will be seen that some important differences occurred between the potentials of the free air and the elm tree collectors. It is significant also that there occurred no difference in the readings between the free air collector and that in the elm tree up to the time when the leaves developed. The few readings which we were able to make in October after the leaves had fallen showed the same results.

Our interpretation of the results of these observations is, that the elm tree took some electricity from the air immediately surrounding it during the period in which it was in foliage. If this single series of observations is typical of what takes place in nature, then we can conclude that the atmospheric electrical potential is not affected much by trees in the immediate vicinity except when they are in foliage. There are a few instances where collectors I. and II. showed

positive potentials, and practically the same relative differences are shown here as in the numerous negative potential readings.

The collector in the branches of the spruce tree, 12 feet from the ground (Collector III.), from which it was well insulated, invariably showed the opposite potential from that obtained in the free air and from the elm tree. It will appear from this that the air surrounding the collector in the spruce tree was charged with the same kind of potential (positive or negative) as that of the earth; and the readings taken from Nos. IV. and V., which were very close to this tree, although four feet higher, gave the same kind of potential as that of Collector III., or larger spruce tree. In other words, all the potentials in Nos. III., IV. and V. are opposite to that of the air. There were some difficulties experienced in obtaining readings of the three spruce trees, — partly because the readings had to be taken too close to the ground, and partly, perhaps, because we were dealing with the same kind of potential in the air that the earth was charged with; and that, therefore, when the potential of the air in the branches of the spruce tree and the potential of the earth were the same in degree and kind, differences in potential would not exist, and therefore measurements would be impossible. Evergreen trees, which are supplied with a large number of pointed leaves, may possibly be better adapted to discharge electricity than deciduous trees. It is quite possible that evergreen trees behave quite differently from deciduous trees as regards their relationship to atmospheric electricity. In our opinion, there is a strong probability that all living plants act as conductors, or that they serve to keep the potential of the earth and the air in more or less equilibrium; and that trees and vegetation in general take part in this, although in all probability all species do not act in the same specific manner.

This phase of the subject has not been studied as much as is desirable. We infer from our own observations that some trees show a great tendency towards conducting the electricity from the air to the earth, and that other trees show the same tendency for conducting electricity from the earth to the air; and that in all probability this exchange of electricity from the air to the earth, and *vice versa*, does not take

place at the same time through the same tree; and that, under normal conditions, — that is, when no great electrical disturbance is taking place, — some species of trees always conduct the electricity to the air from the earth, while other species conduct electricity from the earth to the air. It is not at all unlikely that in the vicinity of large trees there is exhibited a detrimental influence on crops, and vegetation in general, to an extent which cannot be accounted for by the lack of sunshine and soil moisture.

Some Important Literature relating to Diseases, etc., of Crops not generally believed to be caused by Fungi or Insects.

The publication by Dr. W. C. Sturgis[1] of a host index relating to economic fungi has proved of great value to students, and to those interested in the literature pertaining to fungous diseases of our important cultivated crops. Unfortunately, the host index of Dr. Sturgis does not include those troubles generally termed physiological, or those of an unknown nature.

The following list is compiled to supplement his host index to literature pertaining to fungous diseases. It is by no means complete, but includes at least some of the more important publications of the agricultural experiment stations and United States Department of Agriculture relating to functional and unknown disorders.

Apple (*Pirus malus*, L.).

Baldwin Fruit-spot, Brown-spot. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 164, 1899, pp. 215–219. Vt. Agr. Exp. Sta., Rept. 1899; 1900, pp. 159–164.

Frost-blisters (*Leaves*). — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 220, 1902, pp. 217–224. See *Quince*. Mass. Hatch Exp. Sta., Rept. No. 15, 1903, pp. 32–34.

Frost-cracks (*Fruit*). — Vt. Agr. Exp. Sta., Bull. No. 49, 1895, p. 100. See *Pear*.

Rosette. — Col. Agr. Exp. Sta., Bull. No. 69, 1902, pp. 4–6.

Scald. — Vt. Agr. Exp. Sta., Rept. 1896–97, pp. 55–59; also 11th Rept. 1898, pp. 198, 199.

Spraying and Bloom. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 196, 1900.

Spraying Injuries. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 220, 1902, pp. 225–230.

Apricot (*Prunus*).

Leaf-scorch or Sunburn. — Ariz. Agr. Exp. Sta., Rept. 1898, pp. 163–165.

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[1] Conn. (State) Agr. Exp. Sta., Bull. No. 118, 1893; Repts. 17, 1893; 21, 1897; and 24, 1900.

ASTER (*Callistephus hortensis*, Cass.).

Yellows.—Mass. Hatch Exp. Sta., Bull. No. 79, 1902, p. 11.

BEET (*Beta vulgaris*, L.).

Leaf-scorch (*Sugar Beet*).—N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 162, 1899, pp. 167–171.

CAULIFLOWER (*Brassica oleracea*, L.).

Leaf-scorch or Tip-burn.—N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 162, 1899, pp. 176, 177.

CELERY (*Apium graveolens*, L.).

Pithiness.—Maryland Agr. Exp. Sta., Bull. No. 83, 1902; also Bull. No. 93, 1904.

CHERRY (*Prunus Cerasus*, L.).

Leaf-scorch.—N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 162, 1899, pp. 171–176. See *Maple*, etc.

COTTON (*Gossypium*, spp.).

Red Leaf-blight.—Ala. Coll. Sta., Bull. No. 36, 1892, pp. 31, 32.
Shedding of Bolls.—Ala. Coll. Sta., Bull. No. 41, 1892, pp. 50–53.
Yellow Leaf-blight.—Ala. Coll. Sta., Bull. No. 36, 1892, pp. 2–31.

CUCUMBER (*Cucumis sativus*, L.).

Leaf-curl.—Mass. Hatch Exp. Sta., Bull. No. 87, pp. 30, 31.
Stem-curl.—Mass. Hatch Exp. Sta., Bull. No. 87, p. 32.
Wilt.—Mass. Hatch Exp. Sta., Bull. No. 87, p. 32; also Rept. 1899, pp. 159-163.

GRAPE (*Vitis*, spp.).

California Vine Disease.—U. S. Dept. Agr., Div. Veg. Path., Bull. No. 2, 1892. U. S. Dept. Agr., Farmers' Bull. No. 30, pp. 1–11.
Chlorosis.—U. S. Dept. Agr., Div. Veg. Path., Bull. No. 2, 1892, pp. 179–181.
Coulure.—U. S. Dept. Agr., Div. Veg. Path., Farmers' Bull. No. 30, pp. 11–14.
Mal Nero, Rougeot and Folletage.—N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 76, 1894, pp. 420, 421. U. S. Dept. Agr., Div. Veg. Path., Bull. No. 2, 1892, pp. 181–198.
Sunstroke.—Cal. Agr. Exp. Sta., Rept. 1887–93, pp. 450, 451.
Pourriture.—U. S. Dept. Agr., Div. Veg. Path., Bull. No. 2, 1892, pp. 181, 182.
Shelling.—Conn. (State) Agr. Exp. Sta., Rept. 1896, pp. 278–281. Mich. Agr. Exp. Sta., Bull. No. 121, 1895, p. 51. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 76, 1894, pp. 413–440, 452–454.

LETTUCE (*Lactuca sativa*, L.).

Top-burn.—Mass. Hatch Exp. Sta., Bull. No. 69, p. 38; also Rept. 1897, pp. 82–84.

LILY (*Lilium*, spp.).

Bermuda Lily Disease.—U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 14, 1897.

MELON (*Cucumis Melo*, L.).

Top-burn.—Ga. Agr. Exp. Sta., Bull. No. 57, 1902, p. 190.

ORANGES, LEMONS, ETC. (*Citrus*, spp.).

Blight.—U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 8, 1896, pp. 9–14. U. S. Dept. Agr., Journ. Mycol., Vol. VII., 1894, pp. 32–34.
Die-back or Exanthema.—Cal. Agr. Exp. Sta., Bull. No. 138, 1902, pp. 40, 41. Fla. Agr. Exp. Sta., Bull. No. 53, 1900, pp. 157–161. U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 8, 1896, pp. 14–20. U. S. Dept. Agr., Journ. Mycol., Vol. VII., 1894, pp. 29, 30.

Foot-rot or Mal di Gomma. — Fla. Agr. Exp. Sta., Bull. No. 53, 1900, pp. 151–155. U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 8, 1896, pp. 28–33. U. S. Dept. Agr., Journ. Mycol., Vol. VII., 1894, pp. 30–32.

Melanose. — Fla. Agr. Exp. Sta., Bull. No. 53, 1900, pp. 168, 169. U. S. Dept. Agr., Div. Veg. Phys. and Path., Bull. No. 8, 1896, pp. 33–38.

PEACH (*Prunus Persica*, Benth. and Hook.).

Bordeaux Injury. — Conn. (State) Agr. Exp. Sta., 24th Ann. Rept. 1900, pp. 219–254. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 164, 1899, pp. 385–388. See *Plum*. Tenn. Agr. Exp. Sta., Bull., Vol. XV., No. 2, 1902.

Dropsical Swellings of Twigs and Branches. — Ohio Agr. Exp. Sta., Bull. No. 92, 1898, pp. 206–208.

Fruit-crack or Sun-scald. — Col. Agr. Exp. Sta., Bull. No. 41, 1898, pp. 15–18.

Gum Disease. — Mich. Agr. Exp. Sta., Rept. 1896, pp. 123, 124; also Rept. 1897, p. 96. Mich. Agr. Exp. Sta., Bull. No. 156, 1898, p. 304.

Little Peach. — Mich. Agr. Exp. Sta., Rept. 1896. pp. 121, 122; also Bull. No. 156, 1898, pp. 303, 304.

Mechanical Injuries, etc. — Ohio Agr. Exp. Sta., Bull. No. 92, 1898, pp. 189, 190.

Rosette. — Ga. Agr. Exp. Sta., Bull. No. 42, 1898, p. 221. Maryland Agr. Exp. Sta., Bull. No. 42, 1896, pp. 160–162. Oklahoma Agr. Exp. Sta., Bull. No. 20, 1896, p. 21. U. S. Dept. Agr., Div. Veg. Path., Bull. No. 1, 1891. U. S. Dept. Agr., Farmers' Bull. No. 17, pp. 13–17. U. S. Dept. Agr., Journ. Mycol., Vol. VI., pp. 143–148. U. S. Dept. Agr., Journ. Mycol., Vol. VII., 1894, pp. 226–232.

Twig Diseases, — Gum-flow. — Ohio Agr. Exp. Sta., Bull. No. 92, 1898, pp. 199–206.

Twig Spots. — Ohio Agr. Exp. Sta., Bull. No. 92, 1898, p. 208.

Yellows. — Conn. (State) Agr. Exp. Sta., Bull. No. 111, 1892, pp. 7, 8; also Bull. No. 115. Delaware Agr. Exp. Sta., Rept. 1893, pp. 152, 153; also Rept. 1897, pp. 168–173. Ga. Agr. Exp. Sta., Bull. No. 42, 1898, p. 220. Maryland Agr. Exp. Sta., Bull. No. 42, 1896, pp. 157–160. Mass. Bull. Bussey Inst. (Harvard Univ.), Vol. III., Pt. 1, 1901. Mass. Hatch Exp. Sta., Bull. No. 8, 1890, pp. 6–12. Mich. Agr. Exp. Sta., Bull. No. 103, 1894, pp. 46–53. N. J. Agr. Exp. Sta., Rept. 1898, pp. 357–359; also Rept. 1899, pp. 417, 418. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 25, 1890, pp. 178–180; also Bull. No. 75, 1894, pp. 392–408. No. Car. Agr. Exp. Sta., Bull. No. 92, 1893, pp. 101, 102, 112; also Bull. No. 120, 1895, pp. 300, 301. Ohio Agr. Exp. Sta., Bull. No. 104, 1899, pp. 212–216; also Bull. No. 92, 1898, pp. 190–199. Pa. Agr. Exp. Sta., Bull. No. 37, 1896, pp. 21–23. U. S. Dept. Agr., Div. Veg. Path., Bull. No. 4, 1893. U. S. Dept. Agr., Div. Veg. Path., Bull. No. 1, 1891. U. S. Dept. Agr., Farmers' Bull. No. 17, 1894. U. S. Dept. Agr., Sec. Veg. Path., Bull. No. 9, 1888. W. Va. Agr. Exp. Sta., Bull. No. 66, 1900, pp. 214, 215.

PEAR (*Pirus communis*, L.).

Frost Injuries. — Col. Agr. Exp. Sta., Bull. No. 41, 1898, pp. 15–18 (tree trunk). See *Plum* and *Peach*. Conn. (State) Agr. Exp. Sta., 19th Rept. 1895, p. 190 (on fruit). Vt. Agr. Exp. Sta., Bull. No. 49, 1895, p. 100 (on fruit). See *Apple*.

PLUM (*Prunus*, spp.).

Frost-cracks and Sun-scald. — Cal. Agr. Exp. Sta., Bull. No. 41, 1898, pp. 15–18. Del. Agr. Exp. Sta., Bull. No. 57, 1902, pp. 13–15.

Gummosis. — Ohio Agr. Exp. Sta., Bull. No. 79, 1897, pp. 121, 122. Oregon Agr. Exp. Sta., Bull. No. 45, 1897, pp. 68–72.

Yellows. — Consult *Peach* literature. Mass. Hatch Exp. Sta., Rept. 1903, p. 35.

POTATO (*Solanum tuberosum*, L.).

Arsenical Poisoning. — Vt. Agr. Exp. Sta., Bull. No. 49, 1895, pp. 97, 98; also Bull. No. 72, 1899, pp. 9, 10.

Internal Brown Rot. — Minn. Agr. Exp. Sta., Bull. No. 39, 1894, pp. 212, 213. Minn. Agr. Exp. Sta., Bull. No. 45, 1895, p. 310. N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 101, pp. 78–83; also Rept. 1896, pp. 504–509.

Pimply Potatoes. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 101, 1896, pp. 84, 85; also Rept. 1896, p. 511.

Stem-blight. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 101, 1896, pp. 83, 84; also Bull. No. 138, 1897, pp. 632–634.

Sun-scald. — Vt. Agr. Exp. Sta., Bull. No. 72, 1899, pp. 12, 13.

Tip-burn. — U. S. Dept. Agr., Farmers' Bull. No. 91, p. 10. Vt. Agr. Exp. Sta., Bull. No. 49, 1895, pp. 98, 99; also Bull. No. 72, 1899, pp. 10–12.

QUINCE (*Pirus Cydonia*).

Frost-blisters (*Leaves*). — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 220, 1902, pp. 224, 225.

RASPBERRY (*Rubus*, spp.).

Yellows. — N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 226, 1902, pp. 362–364.

RICE (*Oryza sativa*, L.).

Blast. — S. C. Agr. Exp. Sta., Bull. No. 41, 1899, pp. 3–7.

ROSE (*Rosa*, spp.).

Bronzing of Leaves. — Mass. Hatch Exp. Sta., Rept. 1899, pp. 156–159. N. J. Agr. Exp. Sta., Rept. 1891, pp. 303, 304.

TOBACCO (*Nicotiana Tabacum*, L.).

Mosaic Disease, "Calico" or Mottled Top. — Conn. (State) Agr. Exp. Sta., Rept. 1898, pp. 242–260; also Rept. 1899, pp. 252–261. U. S. Dept. Agr., Beau. Plant Indus., Bull. No. 18, 1902.

Spotting. — Conn. (State) Agr. Exp. Sta., Rept. 1898, pp. 254–260; also, Rept. 1899, pp. 252–261.

TOMATO (*Lycopersicum esculentum*, Mill.).

Dropping of Buds. — Fla. Agr. Exp. Sta., Bull. No. 21, 1893, pp. 37, 38; also Bull. No. 47, 1898, pp. 148–151.

Hollow Stem. — Fla. Agr. Exp. Sta., Bull. No. 47, 1898, pp. 151–153.

Œdema. — Fla. Agr. Exp. Sta., Bull. No. 47, 1898, pp. 146–148. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 53, 1893. Vt. Agr. Exp. Sta., 6th Rept. 1892, p. 88.

MISCELLANEOUS.

Arsenical Injuries. — Cal. Agr. Exp. Sta., Bull. No. 151, 1903.

Lichens, Mosses, etc. — Fla. Agr. Exp. Sta., Bull. No. 53, 1900, pp. 169–173.

Shade Trees. — Mechanical injuries, etc.: Conn. (State) Agr. Exp. Sta., Bull. No. 131, 1900; also 24th Rept. 1900, pp. 330–351. N. Y. (Cornell Univ.) Agr. Exp. Sta., Bull. No. 205, 1902.

Leaf-scorch or wilt: Vt. Agr. Exp. Sta., 13th Rept. 1899–1900, pp. 281, 282. Mass. Hatch Exp. Sta., Rept. 1897, pp. 81, 82. N. Y. (Geneva) Agr. Exp. Sta., Bull. No. 162, 1899, pp. 177, 178.

Illuminating gas, steam, etc.: Mass. Hatch Exp. Sta., Rept. 1899, pp. 163–167.

Loss of foliage: Mass. Hatch Exp. Sta., Rept. 1899, pp. 153, 154.

Current electricity, lightning: Mass. Hatch Exp. Sta., Bull. No. 91, 1903.

Sunstroke: Kentucky Agr. Exp. Sta., Bull. No. 47, 1893, pp. 6–8.

Smoke and Atmospheric Gases. — Pa. State Coll. Publication (Prof. Buckhout), 1900 (effects on trees). Utah Agr. Exp. Sta., Bull. No. 88, 1903 (effects on crops).

REPORT OF THE METEOROLOGIST.

J. E. OSTRANDER.

At the beginning of the year a change was made in the times of observation, from 7 A.M., 2 P.M. and 9 P.M. to 8 A.M. and 8 P.M. This was done in order to make them synchronous with those of the United States Weather Bureau, this station being one of the voluntary stations of that service. This change has made no appreciable difference in the daily means compared with those of previous years, excepting those of relative humidity, where the omission of the observation near midday seems to have resulted in a higher mean. The effect, however, can be more definitely determined after the change has been in operation for a number of years.

As in previous years, much of the work of this division has been that of observation and transcription of the records in permanent form. The usual bulletins have been regularly issued at the beginning of each month, containing the more important daily records, together with the monthly means, and remarks on any unusual features that occurred. An annual summary will be made a part of the December bulletin.

The local forecasts have been regularly received from the Boston office of the United States Weather Bureau, and the signals displayed from the flag-staff on the tower. This station is furnishing the weekly reports for the "snow and ice" bulletin, as has been done the last few years.

In addition to furnishing the section director of the Weather Bureau with the voluntary observers' reports, as well as our printed bulletin, at his request early in the year all the records at this station were examined and the data tabulated to be used in a climatological directory of the principal stations

of the United States. A phenological record was also kept during the growing season, and two copies furnished the section director as requested.

As a part of the college exhibit for the Louisiana Purchase Exposition at St. Louis, this division prepared a number of charts in water colors, showing many of the meteorological features of the station. Photographs of most of our self-recording instruments were also sent.

Two new clocks for the Draper instruments were purchased during the year, to replace others that had become unreliable.

Mr. F. F. Henshaw retired as observer upon his graduation in June, and was succeeded by the assistant observer, Mr. G. W. Patch.

REPORT OF THE CHEMIST.

DIVISION OF FOODS AND FEEDING.

J. B. LINDSEY.

Chemical Assistants: E. B. HOLLAND, P. H. SMITH and E. S. FULTON.
Inspector of Feeds and Babcock Machines: ALBERT PARSONS.
Dairy Tester: SUMNER R. PARKER.
In Charge of Feeding Experiments: JOSEPH G. COOK.
Stenographer: MABEL C. SMITH.

Part I. — The Work of the Year.

J. B. LINDSEY.

1. Correspondence.

The general character of the correspondence has been much the same as in former years, and the amount has been approximately 4,000 letters and postals, in addition to some 1,000 circulars relative to adulterated mixed feeds.

2. General Laboratory Work.

The work in the laboratory has been of the same character as formerly. The number of determinations of butter fat in milk has greatly increased.

There have been sent in for examination 104 samples of water, 773 of milk, 1,779 of cream, 2 of butter and 153 of feed stuffs. In connection with experiments by this and other divisions of the station, there have been analyzed, in whole or in part, 234 samples of milk and cream and 530 of fodders and feed stuffs. There have also been collected and tested under the provision of the feed law 686 samples of concentrated feed stuffs. This makes a total of 4,261 substances analyzed during the year, as against 3,897 last year and 3,240 in the previous year. Work on the availability of organic nitrogen, not included in the above, has been done for the Association of Official Agricultural Chemists. In addition, 20 candidates have been examined and given certificates to operate Babcock machines, and 2,026 pieces of glassware have been tested for accuracy, of which 200 pieces, or 9.87 per cent., were condemned.

3. Character of Laboratory Work.

(*a*) *Water.*

In accordance with instructions from the experiment station committee, this department continues to charge the sum of $3 for a sanitary analysis of water. The number of samples

examined has been 104, which is considerably less than when the work was done free of cost. It is believed that this charge has held in check those who have heretofore abused the privilege by sending in a large number of samples, in some cases out of mere curiosity.

Instructions for securing an analysis of water: —

Those wishing to secure a sanitary analysis of water must first make application, whereupon a glass bottle securely encased, accompanied by full instructions for collecting and shipping the sample, will be forwarded by express. The return express must in all cases be prepaid. Because of the smallness of the sum involved, no account will be opened. Remittance by check, P. O. money order, or money at the owner's risk, must be strictly in advance.

Address Dr. J. B. Lindsey,
Hatch Experiment Station, Amherst, Mass.

(*b*) *Dairy Products and Cattle Feeds.*

The station received about the usual number of samples of milk and cream. Many samples are sent by farmers to ascertain the quality of milk produced by their herd or by individual cows, and this should meet with every encouragement. Printed circulars are sent in answer to inquiries, giving concise information concerning the quality of milk produced by different breeds, as well as full instructions relative to the best methods of determining the productive capacity of the dairy herd. The station also tests a large number of samples of milk and cream for creameries at a charge sufficient to cover the cost.

About the usual number of feed stuffs were received during the year. These come from practical feeders, who either suspect adulteration, or desire to know the value of a feed new to their locality. The results of the examination are returned promptly, together with such information as is suited to the particular case. A considerable number of samples are also received from feed dealers, who wish to make sure as to the intrinsic value of the materials they are offering. It is believed that this desire for information should be encouraged as much as the limited resources of the department permit.

(c) *Chemical Investigations.*

In so far as time and opportunity permit, the department aims to make a study of chemical methods that will facilitate the accurate and rapid determinations of the different substances connected with animal or plant life. In this study of methods the department co-operates yearly with the Association of Official Agricultural Chemists.

4. Inspection of Concentrates.

The passage of the feed law by the Legislature of 1903 makes it possible to give the attention to this line of work which its importance demands. A regular inspector is now employed, who travels through the State from six to eight months in the year, so that the station is kept well informed regarding the variety and character of the feeds offered for sale. The results of the several inspections were published in Bulletins Nos. 93 and 98, issued in January and August. These bulletins contained 52 and 36 pages respectively. It may be said that the major portion of the feeds now offered are properly branded and free from adulteration; still, some manufacturers and local dealers continue to be careless about attaching the proper form of guarantee, and, while the station has not prosecuted any cases as yet, there will be no hesitation in doing so if occasion makes it necessary.

A tendency is noted on the part of both manufacturers and dealers to mix more or less oat offal or other filler with standard by-products, thus reducing the cost of the article sufficiently to enable them to slightly undersell their competitors. The station is taking a firm stand against such deceptions.

During the present autumn a considerable quantity of wheat mixed feed, bran and middlings, was found considerably adulterated with ground corn cobs and wheat screenings. The prompt attention of the jobbers was called to the matter, and they took steps immediately to attach the proper guarantee. A special circular relative to this fraud was sent to all the principal grain dealers in the State, as well as to the agricultural press.

It is not necessary to make a chemical analysis of as many samples as formerly. More attention is being given to the work of careful inspection and to the collecting of those samples which are suspected of being below standard or adulterated. The correspondence in connection with this police work, as it may be termed, requires a great deal of time and patience. It is believed that all farmers and dairymen can now keep themselves well posted upon the character and value of the large variety of feeds offered, if they are disposed to do so. Interested parties are referred to the various feed bulletins for details. Bulletin No. 101, comprising the results of the autumn inspection, is now in press, and will be issued during the present month (December).

5. Execution of the Dairy Law.

The enforcement of this law has been given the same careful attention as in previous years.

Inspection of Glassware. — All glassware found to be correctly graduated has been marked "Mass Ex St." There were 2,026 pieces examined, of which 200, or 9.87 per cent., were condemned. Inaccurate graduation of bottles has been rather more noticeable of late than at any time since the early days of the inspection. This is to be regretted, and it is hoped the manufacturers will take immediate action to prevent a possible recurrence. Bulb cream bottles (Bartlett) have been previously passed on accuracy of total graduation, as the usual charge of 5 cents apiece would not permit of additional testing. The continued use of these bottles by some of the prominent milk depots has rendered it necessary to test the three distinct portions of the scale, at a corresponding increase in cost.

Examination of Candidates. — A few more candidates than usual were examined, and 20 certificates of competency issued. A considerable number showed very poor manipulation, and lacked a thorough understanding of the method. In case of failure, applicants are obliged to wait a month before a second examination will be given.

Inspection of Babcock Machines. — The inspection of machines the present year has been in charge of Mr. Albert Parsons, who makes the following report: —

The annual inspection of Babcock machines was made in November of 1904. Fifty-six establishments were either visited or heard from, 36 being creameries and 20 milk depots. Twenty-one, or one-third the number, are co-operative, while the other 35 are proprietary, or managed by stock companies. Thirty-six machines were inspected. The number is 4 less than last year, due to the fact that 2 creameries and 1 milk depot have been discontinued, and 1 milk depot does not use its tester. Some machines overheated the tests, and a few required additional steam to warm them. One needed slight repairs of the steam gauge, but the others were in satisfactory condition, and in general showed an improvement over last year. Steam was the motive power in every case except one, where electricity was used. All but 5 of the machines have frames of cast iron, which is taking the place of galvanized iron and copper. Of the cast-iron machines, 19 are "Facile," 10 "Agos," and 2 "Wizard." The last named has only recently been placed upon the market. As a rule, the glassware was found in good condition, although in a few cases it was very dirty. In addition to the regular inspection, two city milk inspectors were visited. Each had a "Wizard" cast-iron machine, one being run by electricity and the other by a water motor. The electrical machine did not have sufficient power for the necessary speed. The other was in good condition, and a certificate was given.

6. Tests of Pure-bred Cows.

This work has increased to such an extent as to render necessary the employment of a regular tester, Mr. Sumner R. Parker of the class of 1904 of this college, who gives it his whole time. The testing is conducted under the supervision of the American Guernsey and Jersey cattle clubs and the Holstein-Friesian Association. The work consists largely in determining the yearly milk and butter fat yields of pure-bred cows of the several breeds. The inspector visits the farms monthly, weighs the milk for one or two days, determines the butter fat by the Babcock method, and reports his findings to the secretary of the respective clubs, together with such other data, relative to feed, scattered milkings, etc., as are required. These tests are known as "yearly milk and butter fat tests," or "authenticated butter fat estimate and milk record." There are at present

51 Guernsey and Jersey cows under test, belonging to F. Lothrop Ames of North Easton, N. I. Bowditch of Framingham, W. L. Cutting of Pittsfield, R. F. and A. H. Parker of Westborough, A. H. Sagendorph of Spencer, C. I. Hood of Lowell, A. F. Pierce of Winchester, N. H., and R. A. Sibley of Spencer.

In addition, seven-day butter tests are occasionally called for by the Jersey Cattle Club, in which case it becomes necessary to weigh, sample and test not only the milk but the skim milk, buttermilk and butter; and the total fat in the three latter, together with that in the test samples, should balance the fat in the original milk, with the exception of small mechanical losses. The butter is analyzed at the station laboratory. Seven-day tests are also made for the Holstein-Friesian Association, which simply calls for the amount of milk and butter fat produced by the animal during that period.

7. Work completed and in Progress.

In addition to Bulletins Nos. 93 and 98, devoted to the inspection of feeding stuffs, this department has published during the year Bulletin No. 94, on distillery and brewery by-products, and Bulletin No. 99, on dried molasses beet pulp, and nutrition of horses. An experiment has been completed on the use of dried blood as a source of protein for milk production, showing that digestible protein in this material is equal in feeding value to a similar amount in cotton-seed meal. An experiment has also been completed with Pratts food as an aid to milk production. The results make clear that the claims put forward by the manufacturers relative to the wonderful influence of this food in increasing the quantity and quality of milk are entirely without foundation. Bibby's dairy cake has also been compared with gluten feed for the production of milk, and, while the results are not yet entirely tabulated, it is quite evident that the Bibby cake possesses no particular merits over other feed stuffs of a similar composition, and that the price asked is out of proportion to its actual feeding value. A number of experiments have been in progress with green forage crops, but, as the results at present are only of a tentative charac-

ter, they will not be published until it is possible to deduce more definite conclusions.

Some 34 tons of corn and soy beans were grown together the past season on a little less than 3 acres of land, and the fodder ensiled. The silo has been recently opened, the silage appears in good condition and is readily eaten. It was not found possible to cut this mixture satisfactorily with a corn harvester, and the writer is forced to the conclusion that, until this can be accomplished, it will be doubtful economy to attempt to grow it to any extent for silage purposes. It is believed that the value of the extra protein obtained is more than offset by the increased cost of harvesting the crop.

Experiments are in progress relative to the value of molasses and molasses feeds as food for dairy stock and horses, and will occupy a considerable portion of the winter months. Attention is called to the several completed experiments published in Part II. of this report.

8. Changes in Staff.

Mr. W. E. Tottingham, employed in this department as assistant chemist for a year, resigned September 1 to continue his studies in the chemical department of the college. His work was very satisfactory. Mr. E. S. Fulton of the class of 1904 of the college succeeded Mr. Tottingham. Mr. S. R. Parker, another graduate of the class of 1904, began his duties August 1 as dairy tester. He is kept constantly employed in this line of work.

Part II. — Experiments in Animal Nutrition.

1. Digestion Experiments with Sheep.

J. B. LINDSEY.[1]

This station has given considerable time and study to the digestibility of coarse and concentrated cattle feeds. The first experiments were made in the autumn and winter of 1892–93, and the results published, together with a description of the method employed, in the eleventh report of the Massachusetts State Experiment Station. The results of further experiments were published in the twelfth report. A summary of all experiments made between 1894 and 1902 will be found in the fifteenth report of the Hatch Experiment Station, pp. 82–101. Experiments made during 1902 appeared in the sixteenth report of this station.

The experiments here described were made during the autumn of 1903 and winter and spring of 1904. The full data are here presented, with the exception of the daily production of manure and the daily water consumption, in which cases, to economize space, only averages are presented.

The period extended over fourteen days, the first seven of which were preliminary, collection of fæces being made during the last seven. Ten grams of salt were fed each sheep daily, in addition to the regular ration. Water was before the animals at all times.

Two lots of sheep, grade Southdown wethers, were employed in the several trials, known as the old and the young sheep. The former were five to six years of age, and had been used by the station for a number of years; the latter were dropped in 1902, and were employed for the first time during the autumn and winter of 1903–04.

[1] With E. B. Holland, P. H. Smith, W E. Tottingham and J. G. Cook.

The digestion coefficients for the digestion hay, used in calculating the results of the several experiments with the old sheep, were those obtained with Sheep II. and III., Sheep I. having been disposed of before the digestibility of the hay was determined.

The individual coefficients were used for the young sheep, being obtained from the average of the two trials in the case of Sheep I. and II., and that of the single trial for Sheep III.

Hay Coefficients used (Per Cent.).

	Old Sheep.	Young Sheep.		
		I.	II.	III.
Dry matter,	58.50	49.89	54.34	51.53
Ash,	22.00	13.86	22.60	16.55
Protein,	42.50	37.37	37.72	36.66
Fiber,	61.00	49.98	55.85	53.13
Extract matter,	64.00	56.29	59.77	57.02
Fat,	46.50	38.54	44.19	36.97

In calculating the digestion coefficients when English hay was used, excepting in periods IV., V. and XII., the average analysis of the two samples of hay was employed.

Composition of Feed Stuffs (Per Cent.).

[Dry matter.]

Feeds.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Soy bean fodder,	11.82	20.03	22.12	42.55	3.48
Waste soy bean fodder, Sheep II.,	8.64	4.85	55.47	30.33	.71
Eureka silage corn fodder,	6.19	9.34	27.41	55.52	1.54
Apple pomace,	3.05	5.13	16.10	69.32	6.40
Cotton-seed meal fed with pomace,	6.95	52.16	5.88	25.91	9.10
English hay fed to new sheep,	6.53	6.23	33.00	52.27	1.97
Waste English hay,[1] Sheep III., fine hay and seeds.	29.19	6.76	21.67	40.25	2.13
English hay fed to old sheep,	6.35	6.24	31.95	53.15	2.31
Bibby's dairy cake,	9.14	23.52	9.28	48.06	10.00
Bibby's dairy cake (1903),	8.38	21.39	9.19	50.42	10.62
Alma dried molasses-beet-pulp,	5.64	9.87	17.17	66.74	.58

[1] Contained 21.39 per cent. of salt.

Composition of Feed Stuffs (Per Cent.) — Concluded.

[Dry matter.]

Feeds.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Armour's blood meal,	3.37	95.24	.88	–	.51
Corn meal fed with blood meal,	1.41	9.87	2.09	82.25	4.38
Soy bean meal, coarse ground,	5.73	40.69	4.71	27.77	21.10
Hominy feed,	3.15	11.66	5.46	70.11	9.62
Hominy meal (1903),	3.38	12.23	4.97	69.43	9.99
Eureka silage corn fodder (dry),	7.85	9.82	32.70	47.90	1.73
Waste corn stover, Sheep II.,	9.85	9.16	34.13	45.07	1.79
English hay,[1]	6.46	6.74	32.28	52.16	2.36
Waste English hay, Sheep I.,	6.94	6.17	32.72	52.05	2.12
Waste English hay,[2] Sheep II.,	14.99	6.95	27.41	48.22	2.43

[1] Used in Period XII. [2] Contained 7.38 per cent. of salt.

Composition of Fæces (Per Cent.).

[Dry matter.]

Old Sheep I.

Period.	Feeds.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
I.,	Soy bean fodder,	18.55	8.62	33.83	35.99	3.01
II.,	Eureka silage corn fodder,	9.87	8.77	33.67	46.28	1.41
III.,	Apple pomace,	9.93	18.53	24.38	40.21	6.95
XXVI. (1903),	Bibby's dairy cake,	12.88	14.93	27.19	41.62	3.38
XXVIII. (1903),	Hominy meal,	11.31	13.41	28.49	43.33	3.46

Old Sheep II.

I.,	Soy bean fodder,	19.95	9.44	33.48	34.05	3.08
II.,	Eureka silage corn fodder,	11.47	9.85	31.70	45.30	1.68
III.,	Apple pomace,	9.93	17.97	23.24	41.07	7.79
V.,	English hay,	11.78	8.42	30.93	46.03	2.84
VII.,	Alma dried molasses-beet-pulp,	12.37	10.80	29.21	44.15	3.47
IX.,	Soy bean meal,	12.87	9.82	29.50	44.64	3.17
XI.,	Eureka silage corn fodder (dry),	12.73	11.58	26.04	47.87	1.78
XXVI. (1903),	Bibby's dairy cake,	13.89	14.86	26.54	41.23	3.48
XXVIII. (1903),	Hominy meal,	12.91	14.22	25.99	43.21	3.67

Composition of Fæces (Per Cent.) — Concluded.

[Dry matter.]

Old Sheep III.

Period.	Feeds.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
I., . .	Soy bean fodder, ...	19.96	9.34	32.18	35.34	3.18
II., . .	Eureka silage corn fodder, . .	10.92	9.14	32.41	45.89	1.64
III., . .	Apple pomace, ...	11.44	20.82	19.82	40.40	7.52
V., . .	English hay, ...	12.15	9.01	29.49	46.18	3.17
VII., . .	Alma dried molasses-beet-pulp, .	12.51	11.21	27.82	45.04	3.42
IX., . .	Soy bean meal, ...	12.02	10.67	26.56	46.96	3.79
XI., . .	Eureka silage corn fodder (dry), .	12.79	11.84	25.27	48.29	1.81
XXVI. (1903),	Bibby's dairy cake, ...	13.93	15.59	24.63	41.87	3.98
XXVIII. (1903),	Hominy meal, ...	13.06	14.88	24.06	43.41	4.59

Young Sheep I.

IV., . . .	English hay, ...	11.16	7.86	32.51	45.75	2.72
VI., . . .	Bibby's dairy cake, ...	12.62	11.19	30.20	43.41	2.58
VIII., . . .	Armour's blood meal, . . .	10.64	13.03	31.49	42.29	2.55
X., . . .	Marshall's hominy feed, . .	10.98	10.81	29.89	45.47	2.85
XII., . . .	English hay, ...	11.12	8.38	32.64	45.34	2.52

Young Sheep II.

IV., . . .	English hay, ...	10.70	8.40	31.51	46.74	2.65
VI., . . .	Bibby's dairy cake, ...	12.03	12.50	30.29	42.61	2.57
VIII., . . .	Armour's blood meal, . . .	10.47	15.57	29.30	42.23	2.43
X., . . .	Marshall's hominy feed, . .	10.72	11.30	30.08	45.36	2.54
XII., . . .	English hay, ...	11.21	9.26	31.72	45.24	2.57

Young Sheep III.

IV., . . .	English hay, ...	10.92	7.97	32.20	46.40	2.51
VI., . . .	Bibby's dairy cake, ...	12.90	11.08	31.30	42.36	2.36
X., . . .	Marshall's hominy feed, . .	10.62	9.97	30.60	46.14	2.67

Dry Matter Determinations made at Time of Weighing out the Different Foods, and Dry Matter in Manure excreted, determined from Air-dry Fæces (Per Cent.).

Old Sheep I.

Periods.	English Hay.	Soy Bean Fodder.	Eureka Silage Corn Fodder.	Apple Pomace.	Cotton-seed Meal.	Alma Dried Molasses-beet-pulp.	Soy Bean Meal.	Eureka Silage Corn Fodder (Dry).	Bibby's Dairy Cake.	Hominy Meal.	Waste.	Manure.
I., . .	87.27	23.94	–	–	–	–	–	–	–	–	–	91.02
II., . .	–	–	17.42	–	–	–	–	–	–	–	–	89.82
III., . .	87.05	–	–	19.83	89.34	–	–	–	–	–	–	92.28
XXVI. (1903),	88.82	–	–	–	–	–	–	–	89.80	–	–	92.43
XXVIII. (1903),	88.25	–	–	–	–	–	–	–	–	88.48	–	92.98

Old Sheep II.

I., . .	87.27	23.94	–	–	–	–	–	–	–	–	96.37	90.82
II., . .	–	–	17.42	–	–	–	–	–	–	–	–	89.93
III., . .	87.05	–	–	19.83	89.34	–	–	–	–	–	–	92.00
V., . .	88.10	–	–	–	–	–	–	–	–	–	–	92.50
VII., . .	87.82	–	–	–	–	92.62	–	–	–	–	–	93.55
IX., . .	88.37	–	–	–	–	–	86.96	–	–	–	–	94.42
XI., . .	–	–	–	–	–	–	–	40.08	–	–	51.19	93.84
XXVI. (1903),	88.82	–	–	–	–	–	–	–	89.80	–	–	92.66
XXVIII. (1903),	88.25	–	–	–	–	–	–	–	–	88.48	–	92.54

Old Sheep III.

I., . .	87.27	23.94	–	–	–	–	–	–	–	–	–	90.77
II., . .	–	–	17.42	–	–	–	–	–	–	–	–	89.81
III., . .	87.05	–	–	19.83	89.34	–	–	–	–	–	–	91.88
V., . .	88.10	–	–	–	–	–	–	–	–	–	–	92.56
VII., . .	87.82	–	–	–	–	92.62	–	–	–	–	–	93.60
IX., . .	88.37	–	–	–	–	–	86.96	–	–	–	–	94.61
XI., . .	–	–	–	–	–	–	–	40.08	–	–	–	93.84
XXVI. (1903),	88.82	–	–	–	–	–	–	–	89.80	–	–	92.84
XXVIII. (1903),	88.25	–	–	–	–	–	–	–	–	88.48	–	92.91

Dry Matter Determinations, etc. — Concluded.

Young Sheep I.

Periods.	English Hay.	Bibby's Dairy Cake.	Armour's Blood Meal.	Corn Meal.	Marshall's Hominy Feed.	Waste.	Manure.
IV., . .	87.90	–	–	–	–	86.65	93.36
VI., . .	88.05	89.45	–	–	–	–	93.78
VIII., . .	87.85	–	88.70	86.13	–	–	93.45
X., . .	89.30	–	–	–	88.53	–	94.06
XII., . .	89.77	–	–	–	–	87.00	93.22

Young Sheep II.

IV., . .	87.90	–	–	–	–	–	93.27
VI., . .	88.05	89.45	–	–	–	–	93.55
VIII., . .	87.85	–	88.70	86.13	–	–	93.33
X., . .	89.30	–	–	–	88.53	–	93.78
XII., . .	89.77	–	–	–	–	87.80	92.84

Young Sheep III.

IV., . .	87.90	–	–	–	–	88.50	93.25
VI., . .	88.05	89.45	–	–	–	–	94.16
X., . .	89.30	–	–	–	88.53	87.80	94.08

Average Daily Amount of Manure excreted and Water drank (Grams).

Period.	Character of Ration.	Old Sheep I.			Old Sheep II.			Old Sheep III.		
		Manure excreted daily.	Sample Air Dry.	Water drank daily.	Manure excreted daily.	Sample Air Dry.	Water drank daily.	Manure excreted daily.	Sample Air Dry.	Water drank daily.
I.,	Soy bean fodder,	699	35.09	1,409	684	34.26	1,492	679	34.67	1,296
II.,	Eureka silage corn fodder,	630	23.53	–	506	20.70	–	481	21.77	–
III.,	Apple pomace,	669	27.29	536	581	24.68	414	818	25.95	–
V.,	English hay,	–	–	–	806	36.94	1,067	717	33.92	1,391
VII.,	Alma dried molasses-beet-pulp,	–	–	–	613	27.13	1,379	623	28.69	1,386
IX.,	Soy bean meal,	–	–	–	736	27.48	1,264	860	30.62	1,638
XI.,	Eureka silage corn fodder (dry),	–	–	–	400	16.61	516	506	18.55	1,006
XXVI. (1903),	Bibby's dairy cake,	923	31.86	2,370	703	27.13	1,688	784	30.68	1,992
XXVIII. (1903),	Hominy meal,	700	28.73	2,500	825	26.25	2,017	637	23.14	2,198

Average Daily Amount of Manure excreted, etc. — Concluded.

Period.	Character of Ration.	Young Sheep I.			Young Sheep II.			Young Sheep III.		
		Manure excreted daily.	Sample Air Dry.	Water drank daily.	Manure excreted daily.	Sample Air Dry.	Water drank daily.	Manure excreted daily.	Sample Air Dry.	Water drank daily.
IV.,	English hay,	979	39.76	1,309	831	37.47	2,477	875	36.80	1,827
VI.,	Bibby's dairy cake,	956	32.47	1,368	881	32.52	2,156	915	32.99	2,104
VIII.,	Armour's blood meal,	628	27.88	1,369	628	27.72	2,266	–	–	–
X.,	Marshall's hominy feed,	837	29.49	1,339	912	29.16	1,894	844	30.87	2,076
XII.,	English hay,	994	35.08	1,354	799	33.20	2,467	–	–	–

Weights of Animals at Beginning and End of Period (Pounds).

Period.	Character of Ration.	Old Sheep I.		Old Sheep II.		Old Sheep III.	
		Beginning.	End.	Beginning.	End.	Beginning.	End.
I.,	Soy bean fodder,	167.25	168.00	154.50	155.25	152.75	149.50
II.,	Eureka silage corn fodder,	167.50	164.75	156.00	154.50	149.00	145.75
III.,	Apple pomace,	170.75	171.50	157.50	158.25	152.75	153.50
V.,	English hay,	–	–	164.00	162.00	159.50	160.00
VII.,	Alma dried molasses-beet-pulp,	–	–	162.00	162.75	160.50	160.25
IX.,	Soy bean meal,	–	–	163.00	163.25	161.00	158.25
XI.,	Eureka silage corn fodder (dry),	–	–	159.75	157.00	153.75	153.50
XXVI. (1903),	Bibby's dairy cake,	159.00	154.75	155.00	154.25	149.00	146.75
XXVIII. (1903),	Hominy meal,	156.75	152.00	157.25	156.50	150.25	149.00

Weights of Animals, etc. — Concluded.

Period.	Character of Ration.	Young Sheep I.		Young Sheep II.		Young Sheep III.	
		Beginning.	End.	Beginning.	End.	Beginning.	End.
IV.,	English hay,	98.50	95.00	97.00	98.25	97.00	96.00
VI.,	Bibby's dairy cake,	95.25	93.00	93.75	92.25	90.25	90.75
VIII.,	Armour's blood meal,	96.25	97.50	91.25	93.50	–	–
X.,	Marshall's hominy feed,	94.00	94.50	88.00	90.25	89.00	89.25
XII.,	English hay,	98.75	96.50	91.50	94.25	–	–

Period I.

Old Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
400 grams English hay,	349.08	22.48	21.78	113.38	183.97	7.47
2,000 grams soy bean fodder,	478.80	56.59	95.90	105.91	203.73	16.66
Amount consumed,	827.88	79.07	117.68	219.29	387.70	24.13
350.87 grams manure excreted,	319.36	59.24	27.53	108.04	114.94	9.61
Grams digested,	508.52	19.83	90.15	111.25	272.76	14.52
Minus hay digested,	204.21	4.95	9.26	69.16	117.74	3.47
Soy bean fodder digested,	304.31	14.88	80.89	42.09	155.02	11.05
Per cent. digested,	63.56	26.29	84.35	39.74	76.09	66.33

Old Sheep II.

2,000 grams soy bean fodder fed,	478.80	56.59	95.90	105.91	203.73	16.66
Minus 36 grams waste,	34.69	3.00	1.69	19.24	10.52	.25
Soy bean fodder consumed,	444.11	53.59	94.22	86.67	193.21	16.41
400 grams English hay,	349.08	22.48	21.78	113.38	183.97	7.47
Amount consumed,	773.19	76.07	116.00	200.05	377.18	23.88
342.59 grams manure excreted,	311.14	62.07	29.37	104.17	105.94	9.58
Grams digested,	482.05	14.00	86.63	95.88	271.24	14.30
Minus hay digested,	204.21	4.95	9.26	69.16	117.74	3.47
Soy bean digested,	277.84	9.05	77.37	26.72	153.50	10.83
Per cent. digested,	62.51	16.89	82.12	30.83	79.45	66.00

Old Sheep III.

Amount consumed same as for Sheep I.,	827.88	79.07	117.68	219.29	387.70	24.13
346.71 grams manure excreted,	314.71	62.82	29.39	101.27	111.22	10.01
Grams digested,	513.17	16.25	88.29	118.02	276.48	14.12
Minus hay digested,	204.21	4.95	9.26	69.16	117.74	3.47
Soy bean fodder digested,	308.96	11.30	79.03	48.86	158.74	10.65
Per cent. digested,	64.53	19.97	82.41	46.13	77.92	63.93
Average per cent. three sheep digested,	**63.53**	**21.05**	**82.96**	**38.90**	**77.82**	**65.42**

Period II.

Old Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
3,400 grams Eureka silage corn,	592.28	36.66	55.32	162.34	328.83	9.12
235.29 grams manure excreted,	211.34	20.86	18.53	71.16	97.81	2.98
Grams digested,	380.94	15.80	36.79	91.18	231.02	6.14
Per cent. digested,	64.32	43.10	66.50	56.17	70.26	67.32

Old Sheep II.

3,400 grams Eureka silage corn,	592.28	36.66	55.32	162.34	328.83	9.12
207.01 grams manure excreted,	186.16	21.35	18.34	59.01	84.33	3.13
Grams digested,	406.12	15.31	36.98	103.33	244.50	5.99
Per cent. digested,	68.57	41.76	66.85	63.65	74.35	65.68

Old Sheep III.

3,400 grams Eureka silage corn,	592.28	36.66	55.32	162.34	328.83	9.12
217.69 grams manure excreted,	195.51	21.35	17.87	63.36	89.72	3.21
Grams digested,	396.77	15.31	37.45	98.98	239.11	5.91
Per cent. digested,	66.99	41.76	67.70	60.97	72.72	64.80
Average per cent. three sheep digested,	**66.63**	**42.21**	**67.02**	**60.26**	**72.44**	**65.93**

Period III.

Old Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
250 grams English hay,	217.63	14.02	13.58	70.69	114.69	4.66
150 grams cotton-seed meal,	134.01	9.31	69.90	7.88	34.72	12.19
2,000 grams apple pomace,	396.60	12.10	20.35	63.85	274.92	25.38
Amount consumed,	748.24	35.43	103.83	142.42	424.33	42.23
272.89 grams manure excreted,	251.82	25.01	46.66	61.39	101.26	17.50
Grams digested,	496.42	10.42	57.17	81.03	323.07	24.73
Minus hay digested,	127.31	3.08	5.77	43.12	73.40	2.17
	369.11	7.34	51.40	37.91	249.67	22.56
Minus cotton-seed meal digested,	101.85	2.23	61.51	2.52	22.22	11.34
Apple pomace digested,	267.26	5.11	–	35.39	227.45	11.22
Per cent. digested,	67.39	42.23	–	55.43	82.73	44.21

Old Sheep II.

Amount consumed as above,	748.24	35.43	103.83	142.42	424.33	42.33
246.76 grams manure excreted,	227.02	22.54	40.80	52.76	93.24	17.68
Grams digested,	521.22	12.89	63.03	89.66	331.09	24.55
Minus hay and cotton-seed meal digested,	229.16	5.31	67.28	45.64	95.62	13.51
Apple pomace digested,	292.06	7.58	–	44.02	235.47	11.04
Per cent. digested,	73.64	62.64	–	68.94	85.65	43.50

Old Sheep III.

Amount consumed as above,	748.24	35.43	103.83	142.42	424.33	42.23
259.46 grams manure excreted,	238.39	27.27	49.63	47.25	96.31	17.93
Grams digested,	509.85	8.16	54.20	95.17	328.02	24.30
Minus hay and cotton-seed meal digested,	229.16	5.31	67.28	45.64	95.62	13.51
Apple pomace digested,	280.69	2.85	–	49.53	232.40	10.79
Per cent. digested,	70.77	23.55	–	77.57	84.53	42.51
Average per cent. three sheep digested,	**70.60**	**42.81**	–	**67.31**	**84.30**	**43.41**

Period IV.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
850 grams English hay,	747.15	48.79	46.55	246.56	390.54	14.72
Minus 35.86 grams waste,	31.07	2.03	1.94	10.25	16.24	.61
Amount consumed,	716.08	46.76	44.61	236.31	374.30	14.11
397.61 grams manure excreted,	371.21	41.43	29.18	120.68	169.83	10.10
Grams digested,	344.87	5.33	15.43	115.63	204.47	4.01
Per cent. digested,	48.16	11.40	34.59	48.93	54.63	28.42

Young Sheep II.

850 grams English hay,	747.15	48.79	46.55	246.56	390.54	14.72
374.71 grams manure excreted,	349.49	37.40	29.36	110.12	163.35	9.26
Grams digested,	397.66	11.39	17.19	136.44	227.19	5.46
Per cent. digested,	53.22	23.34	36.93	55.34	58.17	37.09

Young Sheep III.

850 grams English hay,	747.15	48.79	46.55	246.56	390.54	14.72
Minus 56.29 grams waste,	39.16	3.89	3.37	10.80	20.05	1.06
Amount consumed,	707.99	44.90	43.18	235.76	370.49	13.66
368.01 grams manure excreted,	343.17	37.47	27.35	110.50	159.23	8.61
Grams digested,	364.82	7.43	15.83	125.26	211.26	5.05
Per cent. digested,	51.53	16.55	36.66	53.13	57.02	36.97
Average per cent. three sheep digested,	**50.97**	**17.10**	**36.06**	**52.47**	**56.61**	**34.16**

Period V.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
900 grams English hay,	792.90	50.35	49.48	253.33	421.43	18.32
369.38 grams manure excreted,	341.68	40.25	28.77	105.68	157.28	9.70
Grams digested,	451.22	10.10	20.71	147.65	264.15	8.62
Per cent. digested,	56.91	20.06	41.86	58.28	62.68	47.05

Old Sheep III.

900 grams English hay,	792.90	50.35	49.48	253.33	421.43	18.32
339.15 grams manure excreted,	313.92	38.14	28.28	92.58	144.97	9.95
Grams digested,	478.98	12.21	21.20	160.75	276.46	8.37
Per cent. digested,	60.41	24.25	42.85	63.45	65.60	45.69
Average per cent. two sheep digested,	**58.66**	**22.16**	**42.36**	**60.87**	**64.14**	**46.37**

Period VI.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay,	528.30	34.02	32.97	171.59	278.41	11.31
200 grams Bibby's dairy cake,	178.90	16.35	42.08	16.60	85.98	17.89
Amount consumed,	707.20	50.37	75.05	188.19	364.39	29.20
324.71 grams manure excreted,	304.51	38.43	34.07	91.96	132.19	7.86
Grams digested,	402.69	11.94	40.98	96.23	232.20	21.34
Minus hay digested,	263.57	4.72	12.32	85.76	156.72	4.36
Bibby's dairy cake digested,	139.12	7.22	28.66	10.47	75.48	16.98
Per cent. digested,	77.76	44.16	68.11	63.07	87.79	94.91

Young Sheep II.

Amount consumed as above,	707.20	50.37	75.05	188.19	364.39	29.20
325.20 grams manure excreted,	304.22	36.60	38.03	92.15	129.63	7.82
Grams digested,	402.98	13.77	37.02	96.04	234.76	21.38
Minus hay digested,	287.08	7.69	12.44	95.83	166.41	5.00
Bibby's dairy cake digested,	115.90	6.08	24.58	.21	68.35	16.38
Per cent. digested,	64.78	37.19	58.41	1.27	79.50	91.56

Young Sheep III.

Amount consumed as above,	707.20	50.37	75.05	188.19	364.39	29.20
329.87 grams manure excreted,	310.61	40.07	34.42	97.22	131.57	7.33
Grams digested,	396.59	10.30	40.63	90.97	232.82	21.87
Minus hay digested,	272.23	5.63	12.09	91.17	158.75	4.18
Bibby's dairy cake digested,	24.36	4.67	28.54	.80	74.07	17.69
Per cent. digested,	69.51	28.56	67.82	–	86.15	98.88
Average per cent. three sheep digested,	**70.68**	**36.64**	**64.78**	**32.17**	**84.48**	**95.12**

Period VII.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay,	526.92	33.93	32.88	171.14	277.69	11.28
300 grams beet pulp,	277.86	15.67	27.42	47.71	185.44	1.61
Amount consumed,	804.78	49.60	60.30	218.85	463.13	12.89
271.34 grams manure excreted,	253.84	31.40	27.41	74.15	112.07	8.81
Grams digested,	550.94	18.20	32.89	144.70	351.06	4.08
Minus hay digested,	308.25	7.46	13.97	104.40	177.72	5.25
Beet pulp digested,	241.69	10.74	18.92	40.30	173.34	–
Per cent. digested,	86.98	68.54	69.00	84.47	93.47	–

Old Sheep III.

Amount consumed as above,	804.78	49.60	60.30	218.85	463.13	12.89
286.94 grams manure excreted,	268.58	33.60	30.11	74.72	120.97	9.19
Grams digested,	536.20	16.00	30.19	144.13	342.16	3.70
Minus hay digested,	308.25	7.46	13.97	104.40	177.72	5.25
Beet pulp digested,	227.95	8.54	16.22	39.73	164.44	–
Per cent. digested,	82.04	54.50	59.15	83.27	88.68	–
Average per cent. two sheep digested,	**84.51**	**61.52**	**64.08**	**83.87**	**91.08**	–

Period VIII.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams English hay,	527.10	33.95	32.89	171.20	277.78	11.28
100 grams corn meal,	86.13	1.21	8.50	1.80	70.84	3.77
100 grams Armour's blood meal,	88.70	2.99	84.48	.78	–	.45
Amount consumed,	701.93	38.15	125.87	173.78	348.62	15.50
278.77 grams manure excreted,	260.51	27.72	33.94	82.03	110.17	6.64
Grams digested,	441.42	10.43	91.93	91.75	238.45	8.86
Minus hay digested,	262.97	4.71	12.29	85.57	156.36	4.35
	178.45	5.72	79.64	6.18	82.09	4.51
Minus corn meal digested,	76.66	–	5.95	–	66.59	3.43
Blood meal digested,	101.79	–	73.69	–	15.50	1.08
Per cent. digested,	100.+	–	88.41	–	–	–

Young Sheep II.

Amount consumed as above,	701.93	38.15	125.87	173.78	348.62	15.50
277.21 grams manure excreted,	258.72	27.09	40.28	75.80	109.26	6.29
Grams digested,	443.21	11.06	85.59	97.98	239.36	9.21
Minus hay and corn meal digested,	363.09	7.67	18.36	95.62	166.03	4.98
Blood meal digested,	80.12	3.39	67.23	2.36	73.33	4.23
Per cent. digested,	90.33	–	79.58	–	–	–
Average per cent. two sheep digested,	–	–	**84.00**	–	–	–

Period IX.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
700 grams English hay,	618.59	39.84	38.59	200.92	326.00	13.24
200 grams soy bean meal,	173.92	9.97	70.77	8.19	48.30	36.70
Amount consumed,	792.51	49.81	109.36	209.11	374.30	49.94
274.77 grams manure excreted,	259.44	33.39	25.48	76.53	115.81	8.22
Grams digested,	533.07	16.42	83.88	132.58	258.49	41.72
Minus hay digested,	361.88	8.76	16.40	122.56	208.64	6.16
Soy bean meal digested,	171.19	7.66	67.48	10.02	49.85	35.56
Per cent. digested,	98.43	76.83	95.35	122.20	103.20	96.89

Old Sheep III.

Amount consumed as above,	792.51	49.81	109.36	209.11	374.30	49.94
306.24 grams manure excreted,	289.73	34.83	30.91	76.95	136.06	10.98
Grams digested,	502.78	14.98	78.45	132.16	238.24	38.96
Minus hay digested,	361.88	8.76	16.40	122.56	208.64	6.16
Soy bean meal digested,	140.90	6.22	62.05	9.60	29.60	32.80
Per cent. digested,	81.01	62.39	87.68	104.90	61.28	89.37
Average per cent. two sheep digested,	**89.72**	**69.61**	**91.51**	**113.55**	**82.24**	**93.13**

Period X.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
550 grams English hay,	491.15	31.63	30.65	159.53	258.84	10.51
250 grams hominy feed,	221.33	6.97	25.81	12.08	155.17	21.29
Amount consumed,	712.48	38.60	56.46	171.61	414.01	31.80
294.91 grams manure excreted,	277.39	30.46	29.99	82.91	126.13	7.91
Grams digested,	435.09	8.14	26.47	88.70	287.88	23.89
Minus hay digested,	244.93	4.38	11.45	79.73	145.70	4.05
Hominy feed digested,	190.16	3.76	15.02	8.97	142.18	19.84
Per cent. digested,	85.87	53.95	58.19	74.25	91.63	93.19

Young Sheep II.

Amount consumed as above,	712.48	38.60	56.46	171.61	414.01	31.80
291.64 grams manure excreted,	273.50	29.32	30.91	82.27	124.06	6.95
Grams digested,	438.98	9.28	25.55	89.34	289.95	24.85
Minus hay digested,	266.89	7.15	11.56	89.10	154.71	4.64
Hominy feed digested,	172.09	2.13	13.99	.24	135.24	20.21
Per cent. digested,	77.75	30.56	54.20	1.99	87.16	94.88

Young Sheep III.

550 grams English hay,	491.15	–	–	–	–	–
Minus 8.86 grams waste hay,	7.78	–	–	–	–	–
Total hay consumed,	483.37	31.13	30.16	157.00	254.74	10.34
250 grams hominy feed,	221.33	6.97	25.81	12.08	155.17	21.29
Amount consumed,	704.70	38.10	55.97	169.08	409.91	31.63
308.66 grams manure excreted,	290.39	30.84	28.95	88.86	133.99	7.75
Grams digested,	414.31	7.26	27.02	80.22	275.92	23.88
Minus hay digested,	249.08	5.15	11.06	83.41	145.25	3.82
Hominy feed digested,	165.23	2.11	15.96	–	130.67	20.06
Per cent. digested,	74.65	30.27	61.84	–	84.21	94.22
Average per cent. three sheep digested,	**79.42**	**38.26**	**58.08**	**38.12**	**87.67**	**94.10**

Period XI.

Old Sheep II.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
1,200 grams Eureka silage corn fodder (dry), .	480.96	37.76	47.23	157.27	230.38	8.32
Minus 96.86 grams waste, ...	49.58	4.88	4.54	16.92	22.35	.89
Amount consumed, ...	431.38	32.88	42.69	140.35	208.03	7.43
166.06 grams manure excreted, ...	155.83	19.84	18.05	40.58	74.60	2.77
Grams digested, ...	275.55	13.04	24.64	99.77	133.43	4.66
Per cent. digested, ...	63.88	39.66	57.72	71.09	64.14	62.72

Old Sheep III.

1,200 grams Eureka silage corn fodder (dry), .	480.96	37.76	47.23	157.27	230.38	8.32
185.54 grams manure excreted, ...	174.11	22.27	20.61	44.00	84.08	3.15
Grams digested, ...	306.85	15.49	26.62	113.27	146.30	5.17
Per cent. digested, ...	63.80	41.02	56.36	72.02	63.50	62.14
Average per cent. two sheep digested, . .	**63.84**	**40.34**	**57.04**	**71.56**	**63.82**	**62.43**

Period XII.

Young Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
800 grams English hay,	718.16	46.39	48.40	231.82	374.59	16.95
Minus 48.57 grams waste,	42.26	2.93	2.61	13.83	22.00	.90
Amount consumed,	675.90	43.46	45.79	217.99	352.59	16.05
350.83 grams manure excreted,	327.04	36.37	27.41	106.75	148.28	8.24
Grams digested,	348.86	7.09	18.38	111.24	204.31	7.81
Per cent. digested,	51.61	16.31	40.14	51.03	57.95	48.66

Young Sheep II.

800 grams English hay,	718.16	46.39	48.40	231.82	374.59	16.95
Minus 32.57 grams waste,	26.27	2.18	1.99	7.84	13.79	.69
Amount consumed,	691.89	44.21	46.41	223.98	360.80	16.26
331.97 grams manure excreted,	308.20	34.55	28.54	97.76	139.43	7.92
Grams digested,	383.69	9.66	17.84	126.22	221.37	8.34
Per cent. digested,	55.46	21.85	38.50	56.35	61.36	51.29
Average per cent. two sheep digested,	**53.54**	**19.08**	**39.32**	**53.69**	**59.66**	**49.98**

Period XXVI. (1903).

Old Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
650 grams hay,	577.33	44.05	69.45	182.44	264.94	16.45
250 grams Bibby's dairy cake,	224.50	18.81	48.02	20.63	113.19	23.84
Total consumed,	801.83	62.86	117.47	203.07	378.13	40.29
318.61 grams manure excreted,	294.49	37.93	43.97	80.07	122.57	9.95
Amount digested,	507.34	24.93	73.50	123.00	255.56	30.34
Minus hay digested,	369.49	19.82	43.75	122.23	174.86	8.88
Bibby's dairy cake digested,	137.85	5.11	29.75	.77	80.70	21.46
Per cent. digested,	61.40	27.16	61.95	–	71.29	90.02

Old Sheep II.

Total consumed as above,	801.83	62.86	117.47	203.07	378.13	40.29
271.31 grams manure excreted,	251.40	34.92	37.36	66.72	103.65	8.75
Amount digested,	550.43	27.94	80.11	136.35	274.48	31.54
Minus hay digested,	369.49	19.82	43.75	122.23	174.86	8.88
Bibby's dairy cake digested,	180.94	8.12	36.36	14.12	99.62	22.66
Per cent. digested,	80.59	43.17	75.72	68.44	88.01	95.05

Old Sheep III.

Total consumed as above,	801.83	62.86	117.47	203.07	378.13	40.29
306.77 grams manure excreted,	284.81	39.67	44.40	70.15	119.25	11.34
Amount digested,	517.02	23.19	73.07	132.92	258.88	28.95
Minus hay digested,	369.49	19.82	43.75	122.23	174.86	8.88
Bibby's dairy cake digested,	147.53	3.37	29.32	10.69	84.02	20.07
Per cent. digested,	65.71	17.92	61.06	51.82	74.23	84.19
Average per cent. three sheep digested,	**69.23**	**29.42**	**66.24**	**60.13**	**77.84**	**89.75**

Period XXVIII. (1903).

Old Sheep I.

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
600 grams hay,	529.50	40.40	63.70	167.32	242.99	15.09
300 grams hominy meal,	265.44	8.97	32.46	13.19	184.29	26.52
Total consumed,	794.94	49.37	96.16	180.51	427.28	41.61
287.33 grams manure excreted,	267.16	30.22	35.83	76.11	115.76	9.24
Amount digested,	527.78	19.15	60.33	104.40	311.52	32.37
Minus hay digested,	338.88	18.18	40.13	112.10	160.37	8.15
Hominy meal digested,	188.90	.97	20.20	-	151.15	24.22
Per cent. digested,	71.16	10.81	62.23	-	82.02	91.33

Old Sheep II.

Total consumed as above,	794.94	49.37	96.16	180.51	427.28	41.61
262.46 grams manure excreted,	242.88	31.36	34.54	63.12	104.95	8.91
Amount digested,	552.06	18.01	61.62	117.39	322.23	32.70
Minus hay digested,	338.88	18.18	40.13	112.10	160.37	8.15
Hominy meal digested,	213.18	-	21.49	5.29	161.96	24.55
Per cent. digested,	80.31	-	66.20	40.11	87.88	92.57

Old Sheep III.

Total consumed as above,	794.94	49.37	96.16	180.51	427.28	41.61
231.44 grams manure excreted,	215.03	28.08	32.00	51.74	93.34	9.87
Amount digested,	579.91	21.29	64.16	128.77	333.94	31.74
Minus hay digested,	338.88	18.18	40.13	112.10	160.37	8.15
Hominy meal digested,	241.03	3.11	24.03	16.67	173.57	23.59
Per cent. digested,	90.80	34.67	74.03	126.38	94.18	88.95
Average per cent. three sheep digested,	**80.76**	**22.74**	**67.49**	-	**88.03**	**90.95**

Summary of Coefficients (Per Cent.).

Ration.	Sheep Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Soy bean fodder,	Old Sheep I.,	63.56	26.29	84.35	39.74	76.09	66.33
	Old Sheep II.,	62.51	16.89	82.12	30.83	79.45	66.00
	Old Sheep III.,	64.53	19.97	82.41	46.13	77.92	63.93
Average,		**63.53**	**21.05**	**82.96**	**38.90**	**77.82**	**65.42**
Eureka silage corn fodder (green).	Old Sheep I.,	64.32	43.10	66.50	56.17	70.26	67.32
	Old Sheep II.,	68.57	41.76	66.85	63.65	74.35	65.68
	Old Sheep III.,	66.99	41.76	67.70	60.97	72.72	64.80
Average,		**66.63**	**42.21**	**67.02**	**60.26**	**72.44**	**65.93**
Eureka silage corn fodder (dry).	Old Sheep II.,	63.88	39.66	57.72	71.09	64.14	62.72
	Old Sheep III.,	63.80	41.02	56.36	72.02	63.50	62.14
Average,		**63.84**	**40.34**	**57.04**	**71.56**	**63.82**	**62.43**
Apple pomace,	Old Sheep I.,	67.39	42.23	–	55.43	82.73	44.21
	Old Sheep II.,	73.64	62.64	–	68.94	85.65	43.50
	Old Sheep III.,	70.77	23.55	–	77.57	84.53	42.51
Average,		**70.60**	**42.81**	–	**67.31**	**84.30**	**43.41**
English hay,	Young Sheep I.,	48.16	11.40	34.59	48.93	54.63	28.42
	Young Sheep II.,	53.22	23.34	36.93	55.34	58.17	37.09
	Young Sheep III.,	51.53	16.55	36.66	53.13	57.02	36.97
Average,		**50.97**	**17.10**	**36.06**	**52.47**	**56.61**	**34.16**
English hay,	Young Sheep I.,	51.61	16.31	40.14	51.03	57.95	48.66
	Young Sheep II.,	55.46	21.85	38.50	56.35	61.36	51.29
Average,		**53.54**	**19.08**	**39.32**	**53.69**	**59.66**	**49.98**
English hay,	Old Sheep II.,	56.91	20.06	41.86	58.28	62.68	47.05
	Old Sheep III.,	60.41	24.25	42.85	63.45	65.60	45.69
Average,		**58.66**	**22.16**	**42.36**	**60.87**	**64.14**	**46.37**
Bibby's dairy cake,	Young Sheep I.,	77.76	44.16	68.11	63.07	87.79	94.91
	Young Sheep II.,	64.78	37.19	58.41	1.27	79.50	91.56
	Young Sheep III.,	69.51	28.56	67.82	–	86.15	98.88
Bibby's dairy cake (1903),	Old Sheep I.,	61.40	27.16	61.95	–	71.29	90.02
	Old Sheep II.,	80.59	43.17	75.72	68.44	88.01	95.05
	Old Sheep III.,	65.71	17.92	61.06	51.82	74.23	84.19
Average,		**69.95**	**33.03**	**65.51**	**46.15**	**81.16**	**92.44**
Alma dried molasses-beet-pulp.	Old Sheep II.,	86.98	68.54	69.00	84.47	93.47	–
	Old Sheep III.,	82.04	54.50	59.15	83.27	88.68	–
Average,		**84.51**	**61.52**	**64.08**	**83.87**	**91.08**	–
Armour's blood meal,	Young Sheep I.,	100.+	–	88.41	–	–	–
	Young Sheep II.,	90.33	–	79.58	–	–	–
Average,		–	–	**84.00**	–	–	–
Medium green soy bean meal.	Old Sheep II.,	98.43	76.83	95.35	122.20	103.20	96.89
	Old Sheep III.,	81.01	62.39	87.68	104.90	61.28	89.37
Average,		**89.72**	**69.61**	**91.51**	**113.55**	**82.24**	**93.13**

Summary of Coefficients (Per Cent.) — Concluded.

Ration.	Sheep Number.	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Marshall hominy feed,	Young Sheep I.,	85.87	53.95	58.19	74.25	91.63	93.19
	Young Sheep II.,	77.75	30.56	54.20	1.99	87.16	94.88
	Young Sheep III.,	74.65	30.27	61.84	–	84.21	94.22
Hominy meal (1903),	Old Sheep I.,	71.16	10.81	62.23	–	82.02	91.33
	Old Sheep II.,	80.31	–	66.20	40.11	87.88	92.57
	Old Sheep III.,	90.80	34.67	74.03	126.38	94.18	88.95
Average,		**80.09**	**32.05**	**62.78**	**60.68**	**87.85**	**92.52**

The Results discussed.

The more important results obtained from the several digestion experiments, the details of which are reported in the previous tables, are discussed as follows: —

Soy Bean Fodder (Brooks Medium Green). — The yield of fodder was light (about 6 tons to the acre), due to the cool summer of 1903. The plants were quite green, thickly set with leaves, well podded and the seed fairly well developed. In common with other legumes at a similar stage of growth, the fodder showed a noticeably high protein percentage, and only moderate quantities of fiber and extract matter. The three sheep ate the fodder readily and digested it quite evenly. Sheep II. refused small quantities of the coarse stems. The results agree fairly well with those already on record.[1]

Summary of Experiment (Per Cent.).

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep I.,	1	1	63.56	26.29	84.35	39.74	76.09	66.33
Sheep II.,	1	1	62.51	16.89	82.12	30.83	79.45	66.00
Sheep III.,	1	1	64.53	19.97	82.41	46.13	77.92	63.93
Average,	1	3	63.53	21.05	82.96	38.90	77.82	65.42
Average, previous experiments,	5	12	[2]65.00	–	75.00	46.00	75.00	48.00
Clover for comparison,	3	7	66.00	–	70.00	54.00	72.00	64.00
Cow peas for comparison,	2	4	[2]68.00	23.00	76.00	60.00	81.00	59.00

[1] See especially Phelps' work in the reports of the Storrs Experiment Station for 1896 and 1898, and the summary reported in Lindsey's compilation, fourteenth report of the Hatch Experiment Station, p. 198.

[2] Organic matter.

The total dry matter of the soy bean fodder appears to be slightly less digestible than that of other legumes, — clover, Canada field peas and cow peas, — due to its characteristic hard, woody stems. Attention is called to the fact that the digestion coefficient of the fiber in the soy beans is relatively low (39 and 46 per cent.), as compared with those for the clover and cow peas (54 and 60 per cent.). Soy beans will find their chief use in the farm economy as a soiling and silage crop. This subject will be discussed more fully at a later date.

Eureka Silage Corn. — This was a large southern dent variety, 12 to 13 feet tall, which is held in high esteem for silage purposes by the farmers of Worcester County. It is claimed that it will produce several matured ears to each stalk under average summer conditions. The season of 1903 was noticeably cool, and when the corn was cut, September 12–18, it was quite green, the kernels just forming. This variety is being further studied during the present season (1904), and its value as compared with the smaller varieties will be discussed in a subsequent report.

The three sheep showed only slight variations in their ability to digest the corn. The following figures show the average results of all trials with immature dent varieties, as compared with Eureka. The results are quite similar, except that the fiber in case of the Eureka showed a slightly lower digestibility.

Summary of Experiment (Per Cent.).

	Number of Different Lots.	Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Dent corn fodder, immature, . .	4	11	68.00	–	66.00	67.00	71.00	68.00
Eureka (present trial), . . .	1	3	67.00	42.00	67.00	60.00	72.00	66.00

Apple Pomace. — In the sixteenth report of this station (pp. 63–80) are given the results of a digestion test with apple pomace. In that experiment the pomace was fed with a reasonable quantity of hay. In the present trial a smaller amount of hay was fed, and in addition each sheep

was given 150 grams of cotton-seed meal, in the hope of increasing the digestibility of the protein in apple pomace.[1] For the sake of comparison, the coefficients obtained in both experiments follow: —

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Former Experiment, Hay and Pomace.						
Sheep I.,	67.29	42.23	–	55.43	82.73	44.21
Sheep II.,	73.64	62.64	–	68.94	85.65	43.50
Sheep III.,	70.77	23.55	–	77.57	84.53	42.51
Average,	70.60	42.81	–	67.31	84.30	43.41
Present Experiment, Hay, Cotton-seed Meal and Pomace.						
Sheep I.,	65.63	60.91	–	35.82	80.31	51.99
Sheep II.,	71.83	47.20	–	63.93	83.59	39.10
Sheep III.,	80.06	56.11	–	84.95	89.53	50.56
Average,	72.51	54.74	–	61.57	84.48	47.22
Average, both trials,	71.50	48.70	–	64.40	84.40	45.30

Both experiments were made with the same lot of sheep. The sheep digested the total dry matter of the pomace rather more evenly in the present than in the former trial. It is evident that Sheep I. was unable to utilize as much as the other two sheep. It will be seen that the fiber, extract matter and fat, comprising the larger part of the dry matter of the pomace, were digested to approximately the same degree in both experiments. The protein content of the pomace is small, about 1 per cent., and it has not been possible by present methods to fix its digestibility. It probably is digested to a considerable degree, although the results do not make it apparent. The several experiments show the pomace to be as digestible as the better grades of corn silage. Its value for feeding purposes will be further discussed under a separate heading.

English Hay. — The hay used in the present series consisted of a mixture of timothy and redtop, cut in late bloom, and well cured. Two different analyses of this hay are reported in the table of composition. It contained rather less

[1] In determining the digestibility of the apple pomace, average digestion coefficients were taken for the cotton-seed meal. See fourteenth report of this station, p. 209.

protein and more fiber than the hay usually employed by us for digestion experiments.

The young sheep (Period IV.) did not digest the hay as fully as did the old sheep (Period V.) The experiment was repeated with two of the young sheep in Period XII., in which case higher coefficients were obtained, though they did not equal those secured with the old sheep. The hay showed a fair digestibility, and no extreme variations were noted among the several sheep in the same trial. The results, however, do not agree as closely as most of the former experiments with hay carried out at this station.

Bibby's Dairy Cake, made by J. Bibby & Sons of Liverpool, Eng., is composed principally of ground cotton-seed, cereals such as barley and wheat, molasses, fenugreek and salt. It has a pleasing taste and smell, and appears to be highly relished by farm animals. The results of two distinct trials are reported, the first made during the winter of 1903 with three old sheep, and the second made during the winter of 1904 with three young sheep. The first sample was purchased from the stock of a retail grain dealer, and the second was obtained directly from a recent importation. Both lots were in good condition, and resembled each other closely in chemical composition. In the second trial the cake was not relished by Sheep III., although he was induced to eat it after a few days. The cake, which was ground before being fed, acted as a laxative, at first producing soft fæces, which gradually hardened as the period advanced.

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep I., old,	61.40	27.16	61.95	–	71.29	90.02
Sheep II., old,	80.59	43.17	75.72	68.44	88.01	95.05
Sheep III., old,	65.71	17.92	61.06	51.82	74.23	84.19
Average, three sheep,	69.23	29.42	66.24	60.13	77.84	89.75
Sheep I., young,	77.76	44.16	68.11	63.07	87.79	94.91
Sheep II., young,	64.78	37.19	58.41	1.27	79.50	91.56
Sheep III., young,	69.51	28.56	67.82	–	86.15	98.88
Average, three sheep,	70.68	36.63	64.78	32.17	84.14	95.11
Average, six sheep,	69.95	33.02	65.51	46.15	80.99	92.43

Especially wide variations are noted in the case of the old sheep. Sheep II. seemed to have a strong digestion, while Sheep I., judging from the results, was slightly out of condition. Such extreme variations are not apparent in case of the young sheep. In both experiments considerable difficulty was experienced in digesting the crude fiber, due probably to the fact that it was derived largely from cotton-seed hulls. The protein was moderately digestible, while the extract matter and fat yielded fairly high coefficients. In general it may be said that the dairy cake was only moderately digested, and possessed a nutritive value similar to standard wheat middlings. An experiment with Bibby's cake fed to four dairy cows has been completed, and the relative commercial and nutritive value of this concentrate will be more fully discussed in that connection.

Dried Molasses-beet-pulp. — This material, manufactured by the Alma Sugar Company of Alma, Mich., consisted of beet pulp and crude molasses dried.[1] In appearance it resembled ordinary black tea. The analysis showed it to be low in protein and high in fiber and extract matter; only traces of fat were found. A more detailed analysis of the product showed that the crude protein consisted of 7.01 per cent. of true albuminoids and 2.90 per cent. of amides; the extract matter contained 13.80 per cent. of cane sugar and 1.83 per cent. of dextrose. The pentosans (18.40 per cent.) were in all probability largely in the form of a hemi-cellulose, and would also be included in the extract matter. The above figures are based on the material in its natural state, with 8.58 per cent. moisture. The results of the experiment with two old sheep follow: —

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep II.,	86.98	68.54	69.00	84.47	93.47	–
Sheep III.,	82.04	54.50	59.15	83.27	88.68	–
Average,	84.51	61.52	64.08	83.87	91.08	–
Corn meal for comparison,	89.00	–	70.00	–	94.00	91.00

[1] See Bulletin No. 99 for a description of the process and a full discussion of its value.

The sheep ate the material readily and digested it without trouble. From the high average digestibility and an experiment with dairy animals elsewhere reported,[1] it is believed the dried pulp has a feeding value about 10 per cent. less than corn meal.

Armour's Blood Meal, especially prepared for cattle feeding, was found to contain 95.24 per cent. of protein and only traces of fat and fiber. Its mechanical condition was all that could be desired. As the detailed experiment shows, it was fed to two young sheep in combination with hay and corn meal. In figuring the digestibility of the blood the coefficients for the corn meal were taken from Lindsey's compilation.[1] The two sheep digested the dry matter of the blood quite thoroughly, namely, 95.14 per cent. The protein was not as thoroughly digested, — 83.99 per cent. ; but this must be more apparent than real, and due to the influence of the other constituents. It is probable that the protein of the hay and corn meal was not quite as thoroughly digested as the coefficients call for, leaving a slight excess undigested, which must of necessity be charged against the blood. This supposition is strengthened by the fact that there is a small plus balance of extract matter and a minus balance of fiber, which show digestible divergences from the established hay and corn meal coefficients. Judging from the digestibility of the dry matter of the blood, we may safely conclude that the blood protein must be quite thoroughly utilized by farm animals. An experiment with dried blood as a source of protein for dairy animals has been completed, and its economic value will be discussed when the results of that experiment are published.

Soy Bean Meal (Brooks Medium Green). — The beans were grown at the station, and coarsely ground before being fed. They were of the usual good quality, containing 40.69 per cent. of protein and 21.10 per cent. fat in dry matter. The coefficients obtained in 1903 follow, and also those secured in the present trial : —

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[1] *Loco citato.*

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep II., old, 1903,	95.46	44.93	92.80	194.62	93.04	95.67
Sheep III., old, 1903,	87.32	41.70	89.34	85.43	89.29	91.34
Average,	91.39	43.32	91.07	140.03	91.17	93.51
Sheep II., old, 1904,	98.43	76.83	95.35	122.20	103.20	96.51
Sheep III., old, 1904,	81.01	62.39	87.68	104.90	61.28	89.37
Average,	89.72	69.61	91.51	113.55	82.24	92.94
Average, four trials,	90.56	56.47	91.29	126.79	86.71	93.23
Average, two German trials for comparison,	[1]85.00	–	87.00	–	62.00	94.00

[1] Organic matter.

The soy bean, in common with other concentrates rich in nitrogen, frequently causes digestive irregularities. In the present trial Sheep III. was not able to digest the feed as thoroughly as Sheep II. The same condition was apparent last year, although not quite as marked. It is evident that the beans are as a rule quite thoroughly digested, especially the protein and fat, which are the two important constituents. The coefficients for the fiber are, of course, incorrect, due probably to the favorable influence of the rich protein concentrate in increasing the digestibility of the hay carbohydrates. The small amount of fiber present — about 5 per cent. — renders a knowledge of the exact percentage digestible of minor importance. The extract matter was also largely digested, — probably 80 or more per cent., — although the trials made thus far have not given sufficiently definite results to enable one to fix any exact coefficient.

Hominy Feed, or Chop. — As used for cattle feeding, this consists of the hull, germ, some of the gluten and soft starch. The two samples tested were of good average quality. The results of six trials are presented. Three of them were made with old sheep in 1903, and three with young sheep in 1904.

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep I., old, 1903, . . .	71.16	10.81	62.23	–	82.02	91.33
Sheep II., old, 1903, . . .	80.31	–	66.20	40.11	87.88	92.57
Sheep III., old, 1903, . . .	90.80	34.67	74.03	126.50	88.03	90.95
Average, ...	80.75	22.74	67.48	–	85.97	91.61
Sheep I., young, 1904, . .	85.87	53.95	58.19	74.25	91.63	93.19
Sheep II., young, 1904, . .	77.75	30.56	54.20	1.99	87.16	94.88
Sheep III., young, 1904, . .	74.65	30.27	61.84	–	84.24	94.22
Average, ...	79.42	38.26	58.07	38.12	87.66	94.09
Average, both experiments,	80.08	30.50	62.77	–	86.81	92.85
Corn meal for comparison, .	89.00	–	70.00	–	94.00	91.00

In the first trial Sheep I. evidently had a somewhat weakened digestion. This condition has already been referred to, and this sheep was dropped during 1904. Sheep III. appeared to have digested the hominy quite thoroughly, while Sheep II. gave results midway between the other two. Just why the three sheep should have shown such variable results with a feed that is supposed to be easily digested, is not clear. In the second trial, with a different sample and with the young sheep, the results also vary more than one would expect. Sheep III. was unable to digest the starchy matter as well as the other two, but made better use of the protein. The percentage of fiber contained in the hominy is relatively small, and the results differ so noticeably that they must be considered worthless. Both lots of sheep utilized the starchy matter and fat to about the same degree; the young sheep failed to digest the protein, as well as the old sheep. The average results of the two experiments must be regarded as giving a fairly good idea of the digestibility of the several fodder groups. It has been assumed hitherto that hominy was as digestible as corn meal; but, in view of the results obtained, this opinion is no longer tenable. The total dry matter of the hominy seems to be about 9 per cent. less digestible than that of the corn. This deficiency apparently falls largely on the protein and extract

matter. Corn meal as found upon the market contains on an average 14 per cent. of water, or 1,720 pounds of dry matter to the ton; while hominy shows 9 per cent. of water, or 1,820 pounds of dry matter to the ton. Applying the digestion coefficients for dry matter obtained in both cases, hominy would yield 1,456 pounds and corn meal 1,531 to the ton, and would show the corn meal to be about 5 per cent. more valuable than the hominy. It is proposed to repeat the digestion test with still another sample, and also to compare the two feeds with milch cows. The fact must not be overlooked that different samples of both grains, more particularly the hominy, are likely to vary somewhat in nutritive value, hence too positive conclusions should not be drawn. On the basis of our present knowledge, it may be said that both feeds have similar nutritive values.

Eureka Silage Corn Fodder. — This was a cured sample of the variety previously described. In composition it differed somewhat from the green sample, by containing more ash, noticeably more fiber and less extract matter. Whether this change was the result of sampling, or whether it was brought about by the curing process, it is difficult to say. In case of the green corn, small lots were cut every two or three days during the experiment, each lot being carefully sampled and moisture determinations made immediately. At the end of the trial equal weights of each sample were mixed, and this mixture held to represent the corn fed during the entire experiment. To secure as fair a sample as possible of the material to be cured, a considerable quantity was cut about the middle of the digestion trial with the green corn, and placed in stooks in the field. The stooks were removed to the barn before snow came. In spite of the care taken, differences in the composition of the two lots would be likely to occur. At the time of feeding the cured material, in early March, it still contained 60 per cent. of water. It was finely cut before feeding, and, though somewhat mouldy on the outside, proved to be in fairly good condition. Because of the unexpected large water content, the sheep did not receive a sufficient amount daily, — 1,200 grams, — although the results show that they suffered no

great loss in live weight during the period. Sheep III. ate the ration clean, while Sheep II. refused a noticeable amount of the coarser portions. The following figures show the results with the dry fodder; for comparison, the results obtained with the green corn are also stated: —

Summary of Experiment (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sheep II., old, dry fodder, .	63.88	39.66	57.72	71.09	64.14	62.72
Sheep III., old, dry fodder, .	63.80	41.02	56.36	72.02	63.50	62.14
Average, ...	63.84	40.34	57.04	71.56	63.82	62.43
Sheep I., old, green fodder, .	64.32	43.10	66.50	56.17	70.26	67.32
Sheep II., old, green fodder, .	68.57	41.76	66.85	63.65	74.34	65.68
Sheep III., old, green fodder, .	66.99	41.76	67.70	60.97	72.72	64.80
Average, ...	66.63	42.21	67.02	60.26	72.44	65.93

The coefficients obtained are concordant, and the experiment may be considered quite satisfactory. In comparing the results of the two experiments, it will be noticed that the dry fodder was not as well digested as the green material. This may be accounted for partly on the ground that the sheep received the green fodder in September, after having been at pasture all summer, while the dried material was fed in March, after they had been in similar experiments for six months; and partly because previous experiments have demonstrated that in case of very coarse fodders sheep digest the green substance a little more thoroughly than the cured. For some reason the fiber in the dry material was more fully digested than in the green substance. This may be due to the fact that in the cured fodder some of the extract matter had been converted into a hemi-cellulose, which resisted the action of the chemical solvents, but yielded to the influence of the digestive fluids. In general, it may be said that the results obtained with the Eureka corn compare very favorably with those obtained by other experimenters with the southern varieties at a similar stage of growth.

2. The Digestibility of Galactan.

REPORTED BY J. B. LINDSEY.[1]

Those carbohydrates that can be removed from plants and seeds by the action of dilute mineral acid and alkali, and that are soluble in F. Schulze's reagent, E. Schulze has termed hemi-celluloses. Under this heading he has brought the mother substances, — dextran, levulan, mannan, galactan, araban and xylan; which yield on inversion the sugars, — dextrose, levulose, mannose, galactose, arabinose and xylose. These hemi-celluloses are intermixed with the true celluloses in the cell walls of the plants and seeds. They have been frequently recognized as reserve material, being used by the embryo during the sprouting of the seed. The levulan and mannan have not been found generally distributed, while the araban and xylan (pentosans) constitute fully one-third of the extract matter of all hays and straws, are quite prominent in the hull and bran of most grain seeds, and are even found in the endosperm and cotyledons of many seeds.

Galactan was first extracted from lucerne seeds by Muntz,[2] and was converted into galactose by boiling with dilute acid. E. Schulze[3] and his co-workers found considerable galactan in the seeds of the blue lupine, and as a result assumed that this hemi-cellulose might be very generally distributed in agricultural plants. Lindsey and Holland[4] determined the

[1] This experiment was carried out by Mr. E. S. Fulton of the class of 1904 of the Massachusetts Agricultural College, who expressed a desire to undertake work of this character for a graduation thesis. The sheep and apparatus belonging to the department of foods and feeding were placed at his disposal. The digestibility of the hay used had already been determined. Mr. Fulton assumed charge of the sheep, and prepared the fæces for analysis in the station laboratory. The analytical work was done at the college laboratory, under the supervision of Prof. C. Wellington. Mr. Fulton expresses his thanks to Professor Wellington and also to Dr. Lindsey and his co-workers for the many helps and suggestions received.

[2] Bul. Soc. Chem. (2), 37, p. 409.

[3] Zeitsch. f. physiol. Chem. Bd. 14, Heft. 3, Zeitsch. f. physiol. Chem. Bd. 16, Hefts. 4 and 5.

[4] Ninth report of the Hatch Experiment Station, pp. 92-96.

percentage of galactan in a large number of hays, straws and concentrated feeds. The results of their work showed the presence of quite small amounts of galactan in the non-leguminous plants and seeds. In the leguminous plants from 3 to 4 per cent. was found, while in leguminous seeds the amount varied from 1½ to 14 per cent.

The method [1] employed was the one proposed by Tollens and his pupils, and consisted in principle of oxidizing a given amount of the plant or seed with a solution of slightly diluted nitric acid, and collecting the resulting mucic acid, after further treatment for the removal of impurities, on a tared filter.

No experiments are on record relative to the digestibility of galactan, hence the undertaking of this trial. Alsike clover seed was selected because it contained a noticeable quantity of galactan. It was ground reasonably fine, and fed in connection with hay, the digestibility of which had been previously determined. The experiment was conducted in the usual way, three young Southdown wethers being employed, and passed off without any disturbances.

Tabulated Data of the Experiment.

Composition of Feed Stuffs (Per Cent.).

[Dry matter.]

Feeds.	Galactan.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Hay,[2]	1.72	6.53	6.23	33.00	52.27	1.97
Clover seed, . . .	8.07	5.88	34.29	13.12	41.42	5.29

Composition of Fæces (Per Cent.).

[Dry matter.]

Sheep.	Feeds.	Galactan.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
I., .	Hay and clover seed,	.99	11.57	11.97	29.27	44.43	2.76
II., .	Hay and clover seed,	.95	11.21	13.11	30.23	42.84	2.61
III., .	Hay and clover seed,	1.02	11.32	12.63	28.94	44.49	2.62
I., .	Hay,[2]	.86	11.16	7.86	32.51	45.75	2.72
II., .	Hay, ...	.76	10.70	8.40	31.51	46.74	2.65
III., .	Hay, ...	1.07	10.92	7.97	32.20	46.40	2.51

[1] *Loco citato.*

[2] The figures for all constituents, excepting galactan, in hay and hay manures were determined in a previous experiment.

Dry Matter Determinations made at the Time of weighing out the Foods, and Dry Matter in Manure excreted, estimated from Air-dry Fæces (Per Cent.).

Sheep.	Feeds.	Hay.	Clover Seed.	Manure.
I., . .	Hay and clover seed, . . .	88.85	91.53	94.05
II., . .	Hay and clover seed, . . .	–	–	93.70
III., . .	Hay and clover seed, . . .	–	–	94.07
I., . .	Hay, ...	–	–	93.36
II., . .	Hay, ...	–	–	93.27
III., . .	Hay, ...	–	–	93.25

Table showing Food fed, Water drank daily, and Daily Amount of Manure excreted.

[Food consumed daily: 600 grams hay, 200 grams clover seed, 5 grams salt.]

Date.	Sheep I.			Sheep II.			Sheep III.		
	Manure excreted daily (Grams).	Sample Air Dry (Grams).	Water drank daily (Cubic Centimeters).	Manure excreted daily (Grams).	Sample Air Dry (Grams).	Water drank daily (Cubic Centimeters).	Manure excreted daily (Grams).	Sample Air Dry (Grams).	Water drank daily (Cubic Centimeters).
March 20,	922.0	33.24	1,590.0	741.0	29.29	2,290.0	663.0	24.66	2,415.0
" 21,	853.0	29.16	1,060.0	888.0	31.98	1,865.0	879.0	31.60	2,410.0
" 22,	829.0	30.11	1,615.0	938.0	28.55	2,500.0	938.0	33.29	2,425.0
" 23,	799.0	29.56	1,350.0	1,059.0	32.02	2,500.0	822.0	32.29	2,400.0
" 24,	738.0	27.60	1,855.0	852.0	28.14	2,500.0	973.0	33.39	2,500.0
" 25,	909.0	31.64	1,950.0	949.0	29.02	2,500.0	964.0	33.93	2,500.0
" 26,	927.0	33.69	1,750.0	1,316.0	33.50	2,500.0	1,050.0	36.21	2,500.0
Average,	853.9	30.71	1,595.7	963.3	30.36	2,379.3	878.4	32.19	2,450.0

	Pounds.
Weight of Sheep I. at beginning of period,	99.25
Weight of Sheep II. at beginning of period,	94.75
Weight of Sheep III. at beginning of period,	91.50
Weight of Sheep I. at end of period,	99.50
Weight of Sheep II. at end of period,	94.00
Weight of Sheep III. at end of period,	91.00

Sheep I.

	Dry Matter (Per Cent.).	Galactan (Per Cent.).	Ash (Per Cent.).	Protein (Per Cent.).	Fiber (Per Cent.).	Nitrogen-free Extract (Per Cent.).	Fat (Per (Cent.).
600 grams hay fed,	533.10	9.17	34.81	33.21	175.92	278.65	10.50
200 grams clover seed,	183.06	14.77	10.76	62.77	24.02	75.82	9.68
Total consumed,	716.16	23.94	45.57	95.98	199.94	354.47	20.18
307.10 grams manure excreted,	288.83	2.86	33.42	34.57	84.54	128.33	7.97
Grams digested,	427.33	21.08	12.15	61.41	115.40	226.14	12.21
Minus hay digested,[1]	265.95	6.90	4.82	12.41	87.93	156.85	4.05
Clover seed digested,	161.38	14.18	7.33	49.00	27.47	69.29	8.16
Per cent. digested,	88.16	96.01	68.12	78.06	114.36	91.39	84.30

Sheep II.

600 grams hay fed,	533.10	9.17	34.81	33.21	175.92	278.65	10.50
200 grams clover seed,	183.06	14.77	10.76	62.77	24.02	75.82	9.68
Total consumed,	716.16	23.94	45.57	95.98	199.94	354.47	20.18
303.60 grams manure excreted,	284.47	2.70	34.03	37.29	86.00	121.87	7.42
Grams digested,	431.69	21.24	11.54	58.69	113.94	232.60	12.76
Minus hay digested,[2]	289.69	7.28	7.87	12.53	98.25	166.55	4.64
Clover seed digested,	142.00	13.96	3.67	46.16	15.69	66.05	8.12
Per cent. digested,	77.57	94.52	34.11	73.54	65.32	87.11	83.88

Sheep III.

600 grams hay fed,	533.10	9.17	34.81	33.21	175.92	278.65	10.50
200 grams clover seed,	183.06	14.77	10.76	62.77	24.02	75.82	9.68
Total consumed,	716.16	23.94	45.57	95.98	199.94	354.47	20.18
321.90 grams manure excreted,	302.81	3.09	34.28	38.24	87.63	134.72	7.93
Grams digested,[3]	413.35	20.85	11.29	57.74	112.31	219.75	12.25
Minus hay digested,	274.71	6.55	5.76	12.17	93.47	158.89	3.88
Clover seed digested,	138.64	14.30	5.53	45.57	18.84	60.86	8.37
Per cent. digested,	75.74	96.82	51.39	72.60	78.43	80.27	86.47

1 Used average coefficient of Sheep I., Periods IV. and XII.
2 Used average coefficient of Sheep II., Periods IV. and XII.
3 Used coefficients of Sheep III., Period IV.

SUMMARY OF THE RESULTS.

Composition of the Feeds (Per Cent.).

	Galactan.[1]	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Hay, ...	1.72	6.53	6.23	33.00	52.27	1.97
Clover seed, . . .	8.07	5.88	34.29	13.12	41.42	5.29

Digestibility of the Feeds (Per Cent.).

	Dry Matter.	Galactan.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Hay (all sheep), . .	53.50	75.35	20.50	37.00	55.00	59.00	42.00
Clover seed, Sheep I.,	88.16	96.01	68.12	78.06	114.36	91.39	84.30
Clover seed, Sheep II.,	77.57	94.52	34.11	73.54	65.32	87.11	83.88
Clover seed, Sheep III.,	75.74	96.82	51.39	72.60	78.43	80.27	86.47
Average, . . .	80.49	95.78	51.21	74.73	86.04	86.26	84.55

The analysis and digestibility of the hay were made in connection with a series of digestion experiments at the station. It appeared to contain rather more galactan than other samples examined.[2]

A previous complete analysis of alsike clover seed does not appear to be recorded. It contained a high percentage of protein and a normal amount of galactan.

The results of the digestion experiment with the three sheep show the *total dry matter* of the clover seed meal to have been fairly well digested, although the coefficients are noticeably lower than those on record for soy beans, peas, vetch and lupine (85 to 90 per cent.).

The galactan in the hay is shown to be 75 per cent. digestible. Because of the small quantity present, the results are of minor importance. All three sheep digested the galactan in the clover seed quite thoroughly. Such a result was to have been expected, for the reason that in the seed the galactan is supposed to be comparatively free from in-

[1] It may be assumed that the galactan belongs almost wholly to the nitrogen-free extract matter.

[2] Whether the substance obtained was pure galactan, or consisted partly of impurities that it was not possible to remove, it is difficult to say. Lindsey and Holland found a trifle less than 1 per cent. in another sample.

crusting substances, which have been shown by various investigators to seriously interfere with the digestibility of the several fodder groups.[1] Naturally, no positive conclusions should be drawn from the present single investigation. Knowing, however, the physiological and chemical character of the galactan, as well as the digestion coefficients obtained with starch and with the pentosans, — bodies of similar character, — it is reasonably safe to conclude that the results secured give a fairly correct idea of the ability of the animal to utilize the galactan group.

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[1] The pentosans, fifteenth report of the Hatch Experiment Station, p. 118.

3. The Feeding Value of Apple Pomace.

BY J. B. LINDSEY.

There is often considerable discussion in the agricultural press and among farmers concerning the value of apple pomace as a food for dairy and beef cattle; with a view to getting a little positive data, this station instituted a number of experiments, the results of which are here briefly stated.

(*a*) *Composition of Apple Pomace* (*Per Cent.*).

	Water.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Sample I., ...	81.40	.73	.94	3.00	13.03	.90
Sample II., ...	80.20	.60	1.01	3.19	13.73	1.27
Corn silage for comparison,	80.00	1.10	1.70	5.40	11.10	.70

It will be seen from the above figures that apple pomace is a carbohydrate feed similar to corn silage. It contains about the same amount of water (four-fifths), rather less protein and fiber, and a larger proportion of extract matter. Whether the extract matter in the pomace is as valuable, pound for pound, as that contained in the corn, has not been thoroughly demonstrated.

(*b*) *Digestibility of Apple Pomace.*

The value of a feed cannot always be measured by its composition. A food is valuable as a source of nutrition only in so far as its various constituents can be digested and assimilated. This station has made two different experiments to ascertain the digestibility of the pomace, and the detailed results are to be found elsewhere in this report. The summary follows: —

Summary of Experiments (Per Cent.).

	Number of Single Trials.	Dry Matter.	Ash.	Protein.	Fiber.	Extract Matter.	Fat.
Apple pomace (first experiment), . .	3	72.5	54.7	–	61.6	84.5	47.2
Apple pomace (second experiment), . .	3	70.6	42.8	–	67.3	84.3	43.4
Average, ...	6	71.5	48.7	–	64.4	84.4	45.3
Dent corn silage (for comparison), . .	17	64.0	–	52.0	62.0	69.0	85.0
Flint corn silage (small varieties), . .	11	75.0	–	65.0	77.0	79.0	82.0

The results show the total dry matter in apple pomace to be about as digestible as in the best grades of silage. The protein content of the pomace is small, — about 1 per cent., — and it has not been possible by present methods to fix its digestibility. Judging from the composition and digestibility of the pomace, one would feel justified in assuming that, pound for pound, it should approach in feeding value an average quality of corn silage.

(*c*) *Experiments with Dairy Animals.*

While this station has not carried out any exhaustive comparative tests with pomace and other coarse feeds, it has fed the pomace a number of seasons to dairy animals. The material was drawn fresh from the mill, and placed in a large pile under cover. A noticeable quantity of juice gradually drained from it, but it kept in good condition for two months. The animals received from 15 to 30 pounds daily, ate it readily, and the results were quite satisfactory. In one case two cows were fed alternately four weeks at a time on grain and hay, and on grain, hay and pomace; 25 pounds of pomace were compared with 5 pounds of hay. During the pomace period the animals produced 1,153 pounds of milk, and gained 24 pounds in live weight; during the hay period, 1,138 pounds of milk, and lost 6 pounds in weight. On this basis, 5 pounds of pomace were more than equivalent to 1 pound of hay. Judging from this feeding test and from the composition and digestibility of the pomace, it seems probable that 4 pounds, when fed in

what is termed a "balanced ration," would be equal in feeding value to 1 pound of good cow hay.

The Vermont Experiment Station has fed apple pomace for four years, using in all twenty cows in the several trials. The pomace was shovelled into the silo, levelled off, and kept in good condition without further care. In some cases it was placed on top of the corn silage after the latter had settled. The quantity fed varied from 10 to 35 pounds daily, with no unfavorable effects. As a result of the several experiments, the Vermont station concludes that the pomace is equivalent in feeding value to an equal weight of average corn silage,[1] and that it is without injurious effect on the flavor of milk and butter.

Farmers are cautioned not to feed too large quantities at first, but to begin with 10 pounds daily, and to gradually increase the quantity to 30 pounds, taking a week or more in which to do it. In this way, danger of a sudden milk shrinkage, or of the animals getting "off feed," as is sometimes reported, may be avoided. Judging from all the data available, it is believed that farmers living in the vicinity of cider mills will find it good economy to utilize the pomace as a food for their dairy stock.

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1 There is doubt in the mind of the writer whether pomace would prove fully equal to well-preserved and well-eared corn silage; it certainly would approach it in feeding value, and ought to be fully utilized.

4. Blomo Feed for Horses.

J. B. LINDSEY AND P. H. SMITH.

Blomo feed [1] is a mixture of ground corn stalks, or similar material, with dried blood and refuse molasses. It is almost black in color, slightly sticky to handle, and of a bulky, fibrous nature. It has been extensively advertised as a satisfactory partial oat substitute for horses, and is guaranteed to contain 15 per cent. protein and 1.19 per cent. fat. Feeds of similar character have been in use for some time in Europe.

Composition of Blomo Feed (Per Cent.).

	Water.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Blomo feed,	20.2	9.0	14.7	12.1	43.3	.7
Oats for comparison,	11.0	2.9	12.9	8.5	59.6	5.1
Corn for comparison,	11.0	1.4	10.8	1.9	70.2	4.7

It will be seen from the foregoing table that Blomo feed contains more protein and decidedly less fat and starchy matter than either oats or corn. Part of the extract matter consists of cane sugar derived from molasses. The ash content is considerably in excess of either oats or corn.

Digestibility of Blomo Feed.

A digestion experiment [2] was recently completed at this station, with the following results: —

Digestion Coefficients (Per Cent.).

	Dry Matter.	Ash.	Protein.	Fiber.	Nitrogen-free Extract.	Fat.
Blomo feed,	66.7	31.4	62.7	61.4	76.0	15.3
Oats for comparison,	72.0	33.0	86.0	31.0	79.0	82.0
Corn (cracked) for comparison,	88.0	–	76.0	–	96.0	73.0

1 Made by the Blomo Manufacturing Company, New York, N. Y.

2 With sheep.

Digestible Nutrients in a Ton (Pounds).

	Protein.	Fiber.	Nitrogen-free Extract.	Fat.	Total Organic Nutrients.
Blomo feed, ...	184	149	658	2	993
Oats for comparison, . . .	222	53	942	84	1,301
Corn meal for comparison, . .	164	–	1,348	69	1,581

It will be seen that the coefficients obtained from the Blomo are noticeably less than those from either corn or oats. The fat coefficient is of minor importance, because of the small quantity present. It is an established fact that horses digest less fiber than sheep, hence the digestion coefficient for the fiber in the Blomo feed, when applied to horses, is probably too high; a coefficient of 50 would be nearer correct.

Applying the digestion coefficients to the composition of the several feeds, and calculating the digestible organic nutrients in 1 ton, it becomes evident that the Blomo contains some 20 per cent. less digestible organic matter than oats, and some 35 per cent. less than corn. This is due to the comparatively undigestible character of the filler employed.

Cost of Digestible Matter in a Ton.

Allowing $32.50 a ton for Blomo ($1.30 an 80-pound bag), $31 a ton for oats (50 cents a bushel of 32 pounds), and $28 a ton for corn meal, the cost of a pound of digestible matter in each of the several feeds would be as follows: —

	Cents.
Blomo, ...	3.28
Oats, ...	2.40
Corn meal, ...	1.77

At the above prices, it will be seen that digestible matter costs nearly twice as much in the form of Blomo feed as when purchased in corn meal, and about one-third more than in the form of oats.

Feeding Trials with Horses.

Four horses belonging to the agricultural division of the station were employed for the purpose. These horses did hard farm work, which naturally varied somewhat in character and amount from time to time.

TRIAL I.

Object. — The object of the trial was to see if the horses would eat Blomo readily, maintain their weight, and keep in as good working condition as when fed their regular ration.

Rations fed. — The ordinary ration, previous to the beginning of the trial, consisted of 6 quarts of oats, 6 quarts of corn, and what hay the animals would eat clean. The trial ration consisted of 6 quarts of Blomo in place of 6 quarts of oats, 6 quarts of corn, and hay. The Blomo and oats should have been compared pound for pound, but through a misunderstanding they were fed quart for quart, so that 4.2 pounds of Blomo were fed against 6 pounds or more of oats.[1] The horses were gradually placed on the Blomo ration. Three ate it readily, while the fourth refused more or less of it at first, but eventually took the entire quantity without objection.

Duration of the Trial. — The trial began March 19 and lasted until July 5. During this time all four horses were kept constantly on the same ration, and in no case did they fail to take the full quantity of Blomo daily.

Weight and Condition of the Horses. — The horses were weighed two mornings weekly before being fed or watered.

Average Weight at Beginning and End of Trial (Pounds).

1904.	No. 1.	No. 2.	No. 3.	No. 4.
March 19,	1,248	1,288	1,368	1,195
July 5,	1,243	1,270	1,358	1,193

The weight varied slightly from week to week, but it is evident that the ration was sufficient to enable the animals to keep in good condition and do the work required.

[1] Unfortunately, this department did not have the direct care of the animals, hence could not closely supervise the details of the trial.

While the trial was in progress it was found that the Blomo feed, which had been obtained directly from the manufacturers, was several per cent. below its protein guarantee. They claimed that this was due to carelessness on the part of their chemist, and forwarded another lot, with the request that it be used in place of the first shipment.

Trial II.

In the second trial the same horses were used.

Object of the Trial. — The object of the trial was to compare the Blomo feed with oats as a partial grain substitute for work horses.

Plan and Duration of the Trial. — The four horses were divided into lots of two each. In the first half of the trial horses Nos. 1 and 4 received the Blomo ration, and horses Nos. 2 and 3 the oat ration. In the second half these conditions were reversed. Each half lasted six weeks, as follows: —

	Blomo Ration.	Oat Ration.	Length (in Weeks).
July 18 through August 28, .	Horses Nos. 1 and 4,	Horses Nos. 2 and 3,	6
September 5 through October 17,	Horses Nos. 2 and 3,	Horses Nos. 1 and 4,	6

Character of Rations. — The rations were in all cases measured out by the regular feeder. The same misunderstanding existed as in the former trial regarding the relative weight of the Blomo and oats, the feeder giving equal measure instead of weight of each. This resulted in the comparison of approximately 4.2 pounds of Blomo with 6 pounds of oats, which was manifestly unfair to the Blomo.

Blomo Ration fed daily.	*Oat Ration fed daily.*
6 quarts Blomo feed.	6 quarts oats.
6 quarts cracked corn.	6 quarts cracked corn.
Hay (judgment of feeder).	Hay (judgment of feeder).

Weights of Horses (Pounds).

Horses.	Blomo.			Oats.		
	Beginning.	End.	Gain or Loss.	Beginning.	End.	Gain or Loss.
No. 1, . . .	1,230	1,245	15+	1,255	1,240	15—
No. 2, . . .	1,295	1,350	55+	1,265	1,290	25+
No. 3, . . .	1,390	1,370	20—	1,325	1,375	50+
No. 4, . . .	1,180	1,205	25+	1,200	1,195	5—
Totals, . .	5,095	5,170	75+	5,045	5,100	55+

These horses made a slight gain in each case, indicating that both rations were rather more than sufficient to furnish the necessary nutrients for the work performed. Because of the uneven character of the work from day to day, it is not possible to say that one ration gave any better results than the other. It can simply be stated that the horses ate the Blomo ration readily, kept in good condition, and did satisfactory work during the trial.

Keeping Quality of Blomo.

The first lot, of 1 ton, obtained in March, contained 21.5 per cent. of moisture. It was fed gradually until late June, when 480 pounds, or about one-quarter, had spoiled. The second lot, of ½ ton, contained 20 per cent. of water, and was fed from early July until late October, during which time 450 pounds, or nearly one-half, had become sour. This lot underwent a slight decomposition during the warm, muggy weather of August and September. It will be quite necessary for the manufacturers to reduce the moisture content to 12 or less per cent., in order to prevent such changes, especially during the warm season.

Conclusions.

1. Blomo feed was eaten readily, excepting that one of the horses objected to it during the first week of the trial.

2. Considerable of the Blomo spoiled on being kept during the warm weather, and it will be necessary for the manufacturers to reduce the moisture content, in order to overcome this difficulty.

3. It contained noticeably less digestible matter than corn or oats, and, at prices usually prevailing, the nutritive matter it contains must be regarded as decidedly expensive.

4. No injurious effect was noted from feeding a considerable quantity of Blomo as a component of the daily ration during a period of seven months. The horses kept in good condition and did satisfactory work.

5. Owing to a misunderstanding, whereby the Blomo and oats were fed measure for measure, instead of weight for weight, it was not possible to directly compare the feeding value of these two feeds.

6. No particular advantage is to be gained from the use of Blomo feed, other than securing a change from the regular corn and oat diet.

REPORT OF THE CHEMIST.

DIVISION OF FERTILIZERS AND FERTILIZER MATERIALS.

CHARLES A. GOESSMANN.
Assistants: HENRI D. HASKINS, RICHARD H. ROBERTSON,[1] EDWARD G. PROULX.

PART I. — Report on Official Inspection of Commercial Fertilizers.
PART II. — Report on General Work in the Chemical Laboratory.

PART I. — REPORT ON OFFICIAL INSPECTION OF COMMERCIAL FERTILIZERS AND AGRICULTURAL CHEMICALS DURING THE SEASON OF 1904.

CHARLES A. GOESSMANN.

The total number of manufacturers, importers and dealers in commercial fertilizers and agricultural chemicals who have secured licenses during the past season is 66 ; of these, 38 have offices for the general distribution of their goods in Massachusetts, 8 in New York, 8 in Connecticut, 3 in Vermont, 2 in Pennsylvania, 2 in Ohio, 1 in Rhode Island, 1 in Canada, 1 in New Jersey, 1 in Maryland and 1 in Arkansas.

Three hundred and twenty-nine brands of fertilizers and agricultural chemicals have been licensed in Massachusetts during the year. Five hundred and seventy-six samples of

[1] Died Sept. 10, 1904.

fertilizers have been collected up to the present time, in our general markets by experienced assistants in the station. Five hundred and twenty-five samples were analyzed at the beginning of December, 1904, representing 295 distinct brands of fertilizers. These analyses were published in two bulletins of the Hatch Experiment Station of the Massachusetts Agricultural College: No. 100, July, and No. 102, November, 1904. Other official samples not included in these two bulletins will be reserved for our next publication in March, 1905. By comparing the above statements with those of our previous annual reports, it will be seen that there is a gradual increase in the number of fertilizers that are licensed in the State of Massachusetts from year to year. This fact would tend to show an increased consumption of these articles, and would emphasize the importance of their annual inspection from a commercial agricultural standpoint. Twenty-three more brands of fertilizers have been licensed during the past season than in the previous year.

The following table gives in compact form an abstract of the results of analyses of official commercial fertilizers: —

	1903.	1904.
(*a*) Where three essential elements of plant food were guaranteed: —		
Number with three elements equal to or above the highest guarantee,	7	7
Number with two elements above the highest guarantee,	19	32
Number with one element above the highest guarantee,	91	111
Number with three elements between the lowest and highest guarantee,	207	190
Number with two elements between the lowest and highest guarantee,	118	146
Number with one element between the lowest and highest guarantee,	42	48
Number with three elements below the lowest guarantee,	2	none
Number with two elements below the lowest guarantee,	24	12
Number with one element below the lowest guarantee,	100	103
(*b*) Where two essential elements of plant food were guaranteed: —		
Number with two elements above the highest guarantee,	2	8
Number with one element above the highest guarantee,	17	16
Number with two elements between the lowest and highest guarantee,	31	20
Number with one element between the lowest and highest guarantee,	13	19
Number with two elements below the lowest guarantee,	1	1
Number with one element below the lowest guarantee,	14	15
(*c*) Where one essential element of plant food was guaranteed: —		
Number above the highest guarantee,	11	16
Number between the lowest and highest guarantee,	13	24
Number below the lowest guarantee,	18	13

From the above table it will be seen that, on the whole, the quality of the fertilizers that have been licensed, collected and examined during the past year is higher than in the previous season of 1903.

Trade Values of Fertilizing Ingredients in Raw Materials and Chemicals, 1903 and 1904 (Cents per Pound).

	1903.	1904.
Nitrogen in ammonia salts,	17.50	17.50
Nitrogen in nitrates,	15.00	16.00
Organic nitrogen in dry and fine-ground fish, meat, blood, and in high-grade mixed fertilizers.	17.00	17.50
Organic nitrogen in fine bone and tankage,	16.50	17.00
Organic nitrogen in medium bone and tankage,	12.00	12.50
Phosphoric acid soluble in water,	4.50	4.50
Phosphoric acid soluble in ammonium citrate,	4.00	4.00
Phosphoric acid in fine-ground fish, bone and tankage,	4.00	4.00
Phosphoric acid in cotton-seed meal, castor pumace and wood ashes,	4.00	4.00
Phosphoric acid in coarse fish, bone and tankage,	3.00	3.00
Phosphoric acid insoluble (in water and ammonium citrate) in mixed fertilizers.	2.00	2.00
Potash as sulfate (free from chloride),	5.00	5.00
Potash as muriate,	4.25	4.25

A comparison of the market costs of the different essential ingredients of plant food for 1904 with the previous year shows the following variation: nitrogen in the form of nitrates is a cent higher per pound; the higher grades of organic nitrogen, including nitrogen classed in high-grade mixed fertilizers, are half a cent higher in cost than for the year 1903; the cost of the different forms of phosphoric acid and potassium oxide remains the same as in the previous year.

As in the past, the above schedule of trade values was adopted by representatives of the Massachusetts, Connecticut, Rhode Island, Maine, Vermont and New Jersey experiment stations, at a conference held during the month of March, 1904, and is based upon the quotations in ton lots of the leading standard raw materials furnishing nitrogen, phosphoric acid and potash, and which go to make up the bulk of our commercial fertilizers. These quotations are taken from the fertilizer markets in centres of distribution in New England, New York and New Jersey during the six months preceding March, 1904.

Table A, on the following page, gives the average analysis of officially collected fertilizers for 1904; Table B gives a compilation of analyses, showing the maximum, minimum and average percentages of the different essential ingredients of plant food found in the special crop fertilizers, so called, put out by the different manufacturers during the season of 1904.

TABLE A. — *Average Analysis of Officially Collected Fertilizers for 1904 (Per Cent.).*

NATURE OF MATERIAL.	Moisture.	NITROGEN IN ONE HUNDRED POUNDS.		PHOSPHORIC ACID IN ONE HUNDRED POUNDS.							POTASSIUM OXIDE IN ONE HUNDRED POUNDS.	
							TOTAL.		AVAILABLE.			
		Found.	Guaranteed.	Soluble.	Reverted.	Insoluble.	Found.	Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.
Complete fertilizers,	10.67	2.96	2.73	4.30	3.66	2.87	10.60	9.11	7.89	7.55	5.47	5.22
Ground bones,	8.70	3.32	2.93	.42	7.37	16.12	23.91	22.24	7.80	8.39	–	–
Tankage,	10.39	7.02	5.49	–	5.11	5.10	10.21	15.20	5.26	–	–	–
Dry ground fish,	9.82	8.44	8.19	–	5.08	3.76	8.84	7.20	5.08	–	–	–
Dissolved bone-black,	10.92	–	–	12.81	3.00	1.70	17.51	15.50	15.81	15.00	–	–
Acid phosphate,	10.92	–	–	10.33	4.46	1.69	16.48	13.90	14.79	12.33	–	–
Wood ashes,	15.98	–	–	–	–	–	1.52	1.10	–	–	4.59	4.83
Cotton-seed meal,	7.44	6.79	7.00	–	–	–	–	–	–	–	–	–
Flax meal,	8.84	5.89	6.08	–	–	–	–	–	–	–	–	–
Nitrate of soda,	1.76	15.34	15.43	–	–	–	–	–	–	–	–	–
Sulfate of ammonia,	.13	20.20	19.00	–	–	–	–	–	–	–	–	–
High-grade sulfate of potash,	.49	–	–	–	–	–	–	–	–	–	49.65	48.00
Muriate of potash,	1.47	–	–	–	–	–	–	–	–	–	50.69	50.00
Dried blood,	15.13	10.80	6.78	–	–	–	–	–	–	–	–	–

TABLE B. — *Compilation of Analyses of Commercial Fertilizers for the Year 1904 (Per Cent.).*

NAME OF FERTILIZER.	Moisture.	NITROGEN IN ONE HUNDRED POUNDS.			TOTAL PHOSPHORIC ACID IN ONE HUNDRED POUNDS.			AVAILABLE PHOSPHORIC ACID IN ONE HUNDRED POUNDS.			POTASSIUM OXIDE IN ONE HUNDRED POUNDS.		
		Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.
Corn fertilizer, ...	11.33	5.38	1.12	2.34	14.82	8.72	11.03	10.76	5.36	8.44	8.96	1.54	3.53
Fruit and vine fertilizer, ...	11.29	3.86	2.46	3.02	13.02	7.82	9.53	9.26	7.08	7.23	11.08	5.62	8.42
Grain fertilizer, ...	9.67	7.81	.84	2.65	11.06	8.12	9.77	9.01	4.37	6.58	10.40	.88	3.82
Grass fertilizer, ...	7.83	5.31	2.49	4.08	14.71	5.06	9.14	13.03	2.68	6.81	11.94	2.20	5.33
Market-garden fertilizer, ...	11.53	4.09	1.73	2.87	11.54	8.65	10.56	9.09	6.91	8.18	10.00	2.08	6.18
Potato fertilizer, ...	11.38	4.68	1.71	2.63	14.44	6.93	10.27	12.58	4.12	8.08	10.08	2.58	5.64
Tobacco fertilizer, ...	10.14	5.97	.66	4.04	14.96	5.50	10.20	11.42	1.76	6.59	15.06	.72	8.13
Onion fertilizer, ...	10.95	3.42	1.61	3.02	12.18	8.24	9.88	8.93	6.84	7.97	10.48	6.78	7.78

A study of Table B teaches the same lessons as in the past. It is a much safer plan to study our fertilizer bulletins, when selecting a supply of commercial fertilizers, than to depend upon mere trade names. Oftentimes the fertilizer costing the most per ton is the cheapest and most economical fertilizer to use if applied to the soil intelligently. Every farmer should know the requirements of his soil, in order to judiciously select his supply of fertilizers. No iron-clad rule can be laid down for selecting fertilizers, as conditions vary so widely on different soils; it is safe to say, however, that for general use those fertilizers should be purchased which furnish the greatest amount of the three essential elements of plant food in a suitable and available form for the same money.

List of Manufacturers and Dealers who have secured Certificates for the Sale of Commercial Fertilizers in the State during the Past Year (May 1, 1904, to May 1, 1905), and the Brands licensed by Each.

The American Agricultural Chemical Co., Boston, Mass.: —
- Brightman's Fish and Potash.
- Double Manure Salt.
- Dissolved Bone-black.
- Dried Blood.
- Dry Ground Fish.
- Fine-ground Bone.
- Fine-ground Tankage.
- Grass and Lawn Top-dressing.
- Ground South Carolina Phosphate.
- High-grade Fertilizer with Ten Per Cent. Potash.
- High-grade Sulfate of Potash.
- Kainit.
- Muriate of Potash.
- Nitrate of Soda.
- Plain Superphosphate.
- Tobacco Starter and Grower.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass.: —
- Abattoir Bone Dust.
- Bradley's Complete Manure for Corn and Grain.
- Bradley's Complete Manure for Onions.
- Bradley's Complete Manure for Potatoes and Vegetables.
- Bradley's Complete Manure for Top-dressing Grass and Grain.
- Bradley's Complete Manure with Ten Per Cent. Potash.
- Bradley's Corn Phosphate.
- Bradley's Eclipse Phosphate.

The American Agricultural Chemical Co. (Bradley Fertilizer Co., branch), Boston, Mass. — *Con.*
- Bradley's English Lawn Fertilizer.
- Bradley's Niagara Phosphate.
- Bradley's Potato Fertilizer.
- Bradley's Potato Manure.
- Bradley's Seeding-down Manure.
- Bradley's X L Superphosphate.
- Columbia Fish and Potash.
- Church's Fish and Potash.

The American Agricultural Chemical Co. (H. J. Baker & Bro., branch), New York, N. Y.: —
- Baker's A A Ammoniated Phosphate.
- Baker's Complete Potato Manure.

The American Agricultural Chemical Co. (Clark's Cove Fertilizer Co., branch), Boston, Mass.: —
- Clark's Cove Bay State Fertilizer.
- Clark's Cove Bay State Fertilizer, G G.
- Clark's Cove Great Planet Manure.
- Clark's Cove King Philip Guano.
- Clark's Cove Potato Fertilizer.
- Clark's Cove Potato Manure.

The American Agricultural Chemical Co. (Crocker Fertilizer and Chemical Co., branch), Buffalo, N. Y.: —
- Crocker's A A Complete Manure.
- Crocker's Corn Phosphate.
- Crocker's Potato, Hop and Tobacco Phosphate.

The American Agricultural Chemical Co. (Cumberland Bone Phosphate Co., branch), Boston, Mass.:—
Cumberland Potato Fertilizer.
Cumberland Superphosphate.

The American Agricultural Chemical Co. (L. B. Darling Fertilizer Co., branch), Pawtucket, R. I.:—
Darling's Blood, Bone and Potash.
Darling's Complete Ten Per Cent. Manure.
Darling's Farm Favorite.
Darling's General Fertilizer.
Darling's Potato and Root Crop Manure.
Darling's Potato Manure.
Darling's Tobacco Grower.

The American Agricultural Chemical Co. (Great Eastern Fertilizer Co., branch), Rutland, Vt.:—
Garden Special.
General Fertilizer.
Grass and Oats Fertilizer.
Northern Corn Special.
Vegetable, Vine and Tobacco.

The American Agricultural Chemical Co. (Pacific Guano Co., branch), Boston, Mass.:—
Pacific High-grade General.
Pacific Nobsque Guano.
Pacific Potato Special.
Soluble Pacific Guano.

The American Agricultural Chemical Co. (Packers' Union Fertilizer Co., branch), Rutland, Vt.:—
Animal Corn Fertilizer.
Gardener's Complete Manure.
Potato Manure.
Universal Fertilizer.
Wheat, Oats and Clover Fertilizer.

The American Agricultural Chemical Co. (Quinnipiac Co., branch), Boston, Mass.:—
Quinnipiac Climax Phosphate.
Quinnipiac Corn Manure.
Quinnipiac Havana Tobacco Fertilizer.
Quinnipiac Market-garden Manure.
Quinnipiac Onion Manure.
Quinnipiac Phosphate.
Quinnipiac Potato Manure.
Quinnipiac Potato Phosphate.

The American Agricultural Chemical Co. (Read Fertilizer Co., branch), New York, N. Y.:—
Read's Farmers' Friend.
Read's High-grade Farmers' Friend.
Read's Practical Potato Special.
Read's Standard.
Read's Vegetable and Vine.

The American Agricultural Chemical Co. (Standard Fertilizer Co., branch), Boston, Mass.:—
Standard Complete Manure.
Standard Fertilizer.
Standard Guano.
Standard Special for Potatoes.

The American Agricultural Chemical Co. (Henry F. Tucker Co., branch), Boston, Mass.:—
Tucker's Original Bay State Bone Superphosphate.
Tucker's Special Potato Fertilizer.

The American Agricultural Chemical Co. (Williams & Clark Fertilizer Co., branch), Boston, Mass:—
Williams & Clark's Americus Phosphate.
Williams & Clark's Corn Phosphate.
Williams & Clark's High-grade Special.
Williams & Clark's Potato Manure.
Williams & Clark's Potato Phosphate.
Williams & Clark's Prolific Crop Producer.
Williams & Clark's Royal Bone Phosphate.

The American Agricultural Chemical Co. (M. E. Wheeler & Co., branch), Rutland, Vt.:—
Corn Fertilizer.
Bermuda Onion Grower.
Grass and Oats Fertilizer.
Havana Tobacco Fertilizer.
Potato Manure.

W. H. Abbott, Holyoke, Mass.:—
Animal Fertilizer.
Eagle Brand.
Tobacco Fertilizer.

The Abbott & Martin Rendering Co., Columbus, O.:—
Abbott's Tobacco and Potato Special.
Harvest King.
Ideal Grain Grower.

The American Cotton Oil Co., New York, N. Y.:—
Cotton-seed Meal.
Cotton-seed Hull Ashes.

American Linseed Co., New York, N. Y.:—
Cleveland Flax Meal.

Armour Fertilizer Works, Baltimore, Md.:—
All Soluble.
Ammoniated Bone with Potash.
Bone Meal.
Blood, Bone and Potash.
Grain Grower.
High-grade Potato.

H. J. Baker and Bro., New York, N Y.: —
Castor Pumace.

Beach Soap Co., Lawrence, Mass.: —
Beach's Advance Brand.
Beach's Fertilizer Bone.
Beach's Reliance.
Beach's Universal.

Berkshire Fertilizer Co., Bridgeport, Conn.: —
Berkshire Complete Fertilizer.
Berkshire Ammoniated Bone Phosphate.
Berkshire Potato and Vegetable Phosphate.

Joseph Breck & Sons, Boston, Mass.: —
Breck's Lawn and Garden Dressing.
Breck's Market-garden Manure.

Bowker Fertilizer Co., Boston, Mass.: —
Bone, Blood and Potash.
Bowker's Ammoniated Food for Flowers.
Bowker's Bone and Wood Ash Fertilizer.
Bowker's Complete Mixture.
Bowker's Double Manure Salts.
Bowker's Farm and Garden Phosphate.
Bowker's Fish and Potash (Square Brand).
Bowker's Ground Bone.
Bowker's High-grade Fertilizer.
Bowker's Hill and Drill Phosphate.
Bowker's Kainit.
Bowker's Lawn and Garden Dressing.
Bowker's Potato and Vegetable Fertilizer.
Bowker's Potash Bone.
Bowker's Market-garden Fertilizer.
Bowker's Potato and Vegetable Phosphate.
Bowker's Soluble Animal Fertilizer.
Bowker's Special Onion Manure.
Bowker's Superphosphate.
Bowker's Sure Crop Phosphate.
Bowker's Tankage.
Bowker's Ten Per Cent. Manure.
Bowker's Tobacco Ash Fertilizer.
Bowker's Tobacco Starter.
Bristol Fish and Potash.
Corn Phosphate.
Dissolved Bone-black.
Dried Blood.
Early Potato Manure.
Fine Dry Ground Fish.
Fish and Potash (D Brand).
Gloucester Fish and Potash.
Muriate of Potash.
Nitrate of Soda.
Stockbridge Special Manures.
Sulfate of Ammonia.

Bowker Fertilizer Co., Boston, Mass. — *Con.*
Sulfate of Potash.
Tobacco Ash Elements.
Wood Ashes.

T. H. Bunch, Little Rock, Ark.: —
Cotton-seed Meal.

Charles M. Cox & Co., Boston, Mass.: —
Cotton-seed Meal.

Chicopee Rendering Co., Springfield, Mass.: —
Pure Ground Bone.
Complete Animal Fertilizer.
Lawn and Garden Dressing.
Tankage.

E. Frank Coe Co., New York, N. Y.: —
American Farmers' Ammoniated Bone.
American Farmers' Complete Manure.
American Farmers' Corn King.
American Farmers' Grass and Grain.
American Farmers' Market-garden Special.
Columbian Corn Fertilizer.
Columbian Potato Fertilizer.
E. Frank Coe's F P Fish and Potash.
E. Frank Coe's Gold Brand Excelsior Guano.
E. Frank Coe's High-grade Ammoniated Bone Superphosphate.
E. Frank Coe's Nitrate of Soda.
E. Frank Coe's Tobacco and Onion Fertilizer.
Celebrated Special Potato.
Excelsior Potato Fertilizer.
New Englander Corn Fertilizer.
New Englander Potato Fertilizer.
Red Brand Excelsior Guano.
X X X Ground Bone.

John C. Dow & Co., Boston, Mass.: —
Dow's Pure Ground Bone.

Eastern Chemical Co., Boston, Mass.: —
Imperial Grass Fertilizer.
Imperial Plant Food.

William E. Fyfe & Co., Clinton, Mass.: —
Canada Unleached Hard-wood Ashes.

R. & J. Farquhar & Co., Boston, Mass.: —
Clay's London Fertilizer.
Thompson's Improved Vine, Plant and Vegetable Manure.

Hargraves Soap Co., Fall River, Mass.: —
Ground Bone Fertilizer.

The Hardy Packing Co., Columbus, O.: —
Hardy's Complete Manure.
Hardy's Tankage, Bone and Potash.
Hardy's Tobacco and Potato Special.

C. W. Hastings, Cambridgeport, Mass.:—
Ferti Flora.

Thomas Hersom & Co., New Bedford, Mass.:—
Bone Meal.
Meat and Bone.

John Joynt, Lucknow, Can.:—
Pure Canada Unleached Hard-wood Ashes.

Lister's Agricultural Chemical Works, Newark, N. J.:—
Lister's Animal Bone and Potash.
Lister's High-grade Special.
Lister's Oneida Special.
Lister's Potato Manure.
Lister's Special Corn.
Lister's Special Potato.
Lister's Success Fertilizer.

Lowell Fertilizer Co., Boston, Mass.:—
Acid Phosphate.
Muriate of Potash.
Nitrate of Soda.
Swift's Lowell Animal Brand.
Swift's Lowell Bone Fertilizer.
Swift's Lowell Dissolved Bone and Potash.
Swift's Lowell Dissolved Bone-black.
Swift's Lowell Empress Brand.
Swift's Lowell Ground Bone.
Swift's Lowell Lawn Dressing.
Swift's Lowell Market Garden.
Swift's Lowell Potato Manure.
Swift's Lowell Potato Phosphate.
Swift's Lowell Tankage.

George E. Marsh & Co., Lynn, Mass.:—
Pure Bone Meal.

Mapes Formula and Peruvian Guano Co., New York, N. Y.:—
Average Soil Complete Manure.
Cauliflower and Cabbage Manure.
Complete Manure (A Brand).
Complete Manure for General Use.
Complete Manure Ten Per Cent. Potash.
Corn Manure.
Economical Potato Manure.
Fruit and Vine Manure.
Grass and Grain Spring Top-dressing.
Lawn Top-dressing.
Potato Manure.
Tobacco Ash Constituents.
Tobacco Manure Wrapper Brand.
Tobacco Starter Improved.
Top-dressing Improved, One-half Strength.
Vegetable Manure or Complete Manure for Light Soils.

D. M. Moulton, Monson, Mass.:—
Ground Bone.

National Fertilizer Co., Bridgeport, Conn.:—
Chittenden's Ammoniated Bone.
Chittenden's Complete Fertilizer.
Chittenden's Fish and Potash.
Chittenden's High-grade Special.
Chittenden's Market Garden.
Chittenden's Potato Phosphate.
Chittenden's Tobacco Manure.

New England Fertilizer Co., Boston, Mass.:—
Corn Phosphate.
Potato Fertilizer.
Superphosphate.

Olds & Whipple, Hartford, Conn.:—
Complete Tobacco Fertilizer.
Vegetable Potash.

R. T. Prentiss, Holyoke, Mass.:—
Complete Fertilizer.

Parmenter & Polsey Fertilizer Co., Peabody, Mass.:—
A A Brand.
Acid Phosphate.
Lawn Dressing.
Grain Grower.
Muriate of Potash.
Nitrate of Soda.
P. & P. Potato.
Plymouth Rock Brand.
Special Fertilizer for Strawberries.
Special Potato.
Sulfate of Potash.

Jacob Reese, Darby, Penn.:—
Odorless Slag Phosphate.

Rogers & Hubbard Co., Middletown, Conn.:—
Hubbard's All Soils and All Crops Fertilizer.
Hubbard's Corn Phosphate.
Hubbard's Grass and Grain Fertilizer.
Hubbard's Oats and Top-dressing.
Hubbard's Potato Phosphate.
Hubbard's Pure Raw Knuckle Bone Flour.
Hubbard's Soluble Corn.
Hubbard's Soluble Potato Manure.
Hubbard's Soluble Tobacco Manure.
Hubbard's Strictly Pure Fine Bone.

Rogers Manufacturing Co., Rockfall, Conn.:—
All Round Fertilizer.
Complete Corn and Onion.
Complete Fish and Potash.

Rogers Manufacturing Co., Rockfall, Conn. — *Con.*
Complete Potato and Vegetable.
High-grade Grass and Grain.
High-grade Oats and Top-dressing.
High-grade Tobacco and Potato.
High-grade Soluble Tobacco.
Nitrate of Soda.
Pure Fine-ground Bone.

Ross Bros., Worcester, Mass.: —
Ross Brother's Lawn Dressing.

N. Roy & Son, South Attleborough, Mass.: —
Complete Animal Fertilizer.

Russia Cement Co., Gloucester, Mass.: —
Essex Complete Manure for Corn, Grain and Grass.
Essex Complete Manure for Potatoes, Roots and Vegetables.
Essex Corn Fertilizer.
Essex Dry Ground Fish.
Essex A I Superphosphate.
Essex Market Garden and Potato Manure.
Essex Odorless Lawn Dressing.
Essex Rhode Island Special for Potatoes and Roots.
Essex Special Tobacco Manure.
Essex Tobacco Starter.
Essex X X X Fish and Potash.
Muriate of Potash.
Nitrate of Soda.

Salisbury Cutlery Handle Co., Salisbury, Conn.: —
Fine Bone.

M. L. Shoemaker & Co., Limited, Philadelphia, Penn.: —
Swift Sure Superphosphate for General Use.
Swift Sure Bone Meal.

Sanderson's Fertilizer and Chemical Co., New Haven, Conn.: —
Sanderson's Corn Superphosphate.
Sanderson's Fine-ground Fish.
Sanderson's Formula A.
Sanderson's Formula B.
Sanderson's Sulfate of Potash.
Sanderson's Potato Manure.
Sanderson's Special with Ten Per Cent. Potash.
Sanderson's Top-dressing for Grass and Grain.

Thomas L. Stetson, Randolph, Mass.: —
Bone Meal.

J. Stroup, Son & Co., Boston, Mass.: —
Canada Hard-wood Unleached Ashes.

A. L. Warren, Northborough, Mass.: —
Warren's Ground Bone.

The Whitman & Pratt Rendering Co., Lowell, Mass.: —
Whitman & Pratt's All Crops.
Whitman & Pratt's Corn Success.
Whitman & Pratt's Potato Plowman.
Whitman & Pratt's Pure Ground Bone.

Wilcox Fertilizer Works, Mystic, Conn.: —
Complete Bone Superphosphate.
Dry Ground Fish.
Fish and Potash.
High-grade Tobacco Special.
Potato Fertilizer.
Potato, Onion and Vegetable.

Sanford Winter, Brockton, Mass.: —
Pure Fine-ground Bone.

J. M. Woodard & Bro., Greenfield, Mass.: —
Tankage.

A. H. Wood & Co., Framingham, Mass.: —
A A Brand.
B B Brand.
C C Brand.

Part II. — Report on General Work in the Chemical Laboratory.

C. A. GOESSMANN.

1. Analyses of materials forwarded for examination.
2. Notes on wood ashes and lime ashes.
3. Notes on phosphatic slag and experiments with native phosphates.

1. Analyses of Materials forwarded for Examination.

This department of our work has been of the same general character as in past years. We have received during the season 283 samples of miscellaneous substances from farmers within our State for analysis; this is 48 more than was received during the season of 1903.

As far as time and facilities permit, we have devoted our attention to the examination of this class of materials, the substances being taken up for analysis in the order of their arrival at this office. During the season of the official inspection of commercial fertilizers, April 1 to November, our time is so completely occupied that work in this class of general materials, for the benefit of individual farmers, has to give place, in a measure, to the control work of inspection. For this reason we would urge those sending samples for free analysis to forward them, so far as possible, between November 1 and April 1, thus insuring more prompt reports in results of analysis.

As in the past, we have taken an active part in the technical work of the Association of Official Agricultural Chemists for the establishment of new methods of analysis. Many determinations were made on samples forwarded by the association to test the efficacy of several new methods of determining potash and the various forms of phosphoric acid.

Following is a list of materials forwarded by farmers and agricultural organizations during the season of 1904 : —

Wood ashes,	50	Steamed bone,	2
Soils,	47	Wool dust,	2
Complete fertilizers,	32	Wool waste,	2
Lime ashes,	14	Dried blood,	2
Tankage,	10	Sewage,	2
Ground bone,	9	Pulp ashes,	1
Nitrate of soda,	8	Cotton compost,	1
Miscellaneous substances,	9	Carbonate of potash-magnesia,	1
Low-grade sulfate of potash,	7	Silicate of potash,	1
Muck,	7	High-grade sulfate of potash,	1
Meadow mud,	7	Nitrate of potash,	1
Cotton-seed meal,	6	Belgian phosphate,	1
Dry ground fish,	5	Raw bone,	1
Mill refuse,	5	Dissolved bone,	1
Manure,	5	Lime and nitrate of soda,	1
Acid phosphate,	4	Guinea pig manure,	1
Peat,	4	Liquid manure,	1
Cotton-hull ashes,	3	Sheep manure,	1
Muriate of potash,	3	Lime refuse from tannery,	1
Lime,	3	Waste lime,	1
Dissolved bone-black,	3	Granulated lime,	1
Cotton-seed droppings,	2	Plaster,	1
Cotton-seed dust,	2	Raw hide dust,	1
Sulfate of ammonia,	2	Cocoa shells,	1
Carbonate of potash,	2	Dandelion roots,	1
Phosphatic slag,	2	Clover roots,	1

2. Notes on Wood Ashes and Lime Ashes.

(*a*) *Wood Ashes.* — Seventeen and one-half per cent. of the materials forwarded for analysis during the season have been wood ashes, being about the same proportion as that for the year 1903. The following abstract of results of analysis shows their general chemical character, also a comparison in results of analysis with the previous year 1903 : —

Analysis of Wood Ashes.

	Number of Samples.	
	1903.	1904.
Moisture from 1 to 10 per cent.,	11	18
Moisture from 10 to 20 per cent.,	14	16
Moisture from 20 to 30 per cent.,	9	8
Moisture above 30 per cent.,	3	3
Potassium oxide above 8 per cent.,	2	2
Potassium oxide from 6 to 7 per cent.,	4	8
Potassium oxide from 5 to 6 per cent.,	8	6
Potassium oxide from 4 to 5 per cent.,	12	12
Potassium oxide from 3 to 4 per cent.,	8	10
Potassium oxide below 3 per cent.,	3	7
Phosphoric acid from 1 to 2 per cent.,	34	30
Phosphoric acid above 2 per cent.,	none	3
Phosphoric acid below 1 per cent.,	3	12
Average per cent. of calcium oxide (lime),	29.39	30.16
Insoluble matter below 10 per cent.,	7	6
Insoluble matter from 10 to 15 per cent.,	12	18
Insoluble matter above 15 per cent.,	17	20

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Wood Ashes for the Seasons of 1903 and 1904.

	Maximum.		Minimum.		Average.	
	1903.	1904.	1903.	1904.	1903.	1904.
Moisture,	37.34	37.85	2.27	none	15.23	14.42
Potassium oxide,	8.15	11.04	1.68	.80	4.76	4.51
Phosphoric acid,	1.80	6.07	.46	.28	1.37	1.37
Calcium oxide,	35.75	42.86	22.33	19.73	29.39	30.16
Insoluble matter,	28.85	47.21	1.40	4.56	15.07	18.35

From the above tables it will be seen that the percentage of potassium oxide in the wood ashes received during the season is, on the average, somewhat less than for the previous season. The average of phosphoric acid is the same; while the average percentage of lime is somewhat higher than for 1903.

A study of these tables will emphasize the importance of buying this class of material on a statement of a guaranteed composition. We would urge all parties to ask for a positive guarantee of the amount of potassium oxide, phosphoric acid and calcium oxide (although our State law does not oblige the manufacturer to guarantee the latter element, it should be required when buying this class of fertilizers) said to be contained in this or similar classes of fertilizers. We would also advise all parties to patronize those dealers and importers who have complied with our State laws by securing a license for the sale of their article in Massachusetts. It is only in this way that protection by our State laws can be secured.

(*b*) *Lime Ashes.* — What has been said regarding wood ashes applies with equal force to lime ashes. They should always be bought on a statement of the guarantee of lime, potash and phosphoric acid which they contain, as they are more apt to vary widely in chemical composition than even wood ashes.

Table showing the Maximum, Minimum and Average Per Cents. of the Different Ingredients found in Lime Ashes for the Seasons of 1903 and 1904.

	Maximum.		Minimum.		Average.	
	1903.	**1904.**	**1903.**	**1904.**	**1903.**	**1904.**
Moisture,	23.16	36.62	10.47	none	15.66	10.88
Potassium oxide,	3.32	2.46	.76	.06	1.86	1.54
Phosphoric acid,	1.66	1.48	.03	trace	.63	.74
Calcium oxide,	55.44	55.24	32.42	21.92	41.15	42.93
Insoluble matter,	26.50	25.47	1.10	2.76	6.46	8.11

From the above comparison it will be seen that the lime ashes during the present season analyzed a little higher in lime and a little lower in potash than in 1903.

3. Notes on Phosphatic Slag and Experiments with Native Phosphates.

In one of our previous annual reports (thirteenth annual report, 1901, of Hatch Experiment Station of Massachusetts Agricultural College, pp. 68–70) we have discussed in detail the history and timely appearance of the basic slag phosphate

in our general markets. In this article we pointed out the special modes of analysis that were in use in testing this material, also certain changes that have taken place in many localities in preparing the phosphatic slag by the addition of silica in a fusing process to change the free lime which is present in the slag to a silicate of lime, thus showing, it is claimed, a larger percentage of available phosphoric acid.

Samples of phosphatic slag have been collected in our general markets during the past year. This would indicate that this class of material was claiming the attention of agriculturists more than in the past. The extensive introduction of new methods of iron manufacture has largely increased the supply of phosphatic slag. Results of field experiments have shown the superior value of this material and demonstrated its fitness as a manurial matter. In view of the above facts, we have again taken this subject up for discussion.

The following table gives the results of analysis of samples of phosphatic slag made at the laboratory during 1904, in comparison with the average of analyses of slags made at the station in years past. Sample I. was imported from England in 1904; Sample II. was collected in our general markets during the spring of 1904; Sample III. was the average of all previous analyses made at the station.

Analysis of Samples (Per Cent.).

	Sample I.	Sample II.	Sample III.
Moisture,	.15	none	.99
Total phosphoric acid,	18.61	20.52	20.61
Available phosphoric acid,	-	4.96	4.05
Insoluble phosphoric acid,	-	15.56	19.02
Calcium oxide,	50.58	46.78	50.32
Insoluble matter,	-	18.78	6.59

From the results of the above compilation of analyses it will be seen that the present phosphatic slag does not differ materially from that of the past. The two samples analyzed during the year showed the presence of free lime, which fact was recognized and the mode of analysis was so modified as to

counteract the action of the free lime before subjecting the samples to the usual treatment with neutral citrate of ammonia for the dermination of the available phosphoric acid.

The attempt to imitate the phosphatic slag, by fusing apatite with soda ash at 600° to 800° C., was mentioned in our previous annual report. Observations have been extended along this line during recent years by fusing natural phosphates with carnallite and kieserite for ten to fifteen minutes, at a temperature of 650° to 800° C. This treatment gave a compound analyzing: —

	Per Cent.
Total phosphoric acid,	20.71
Phosphoric acid soluble in 2 per cent. citric acid solution,	15.23
Calcium oxide,	9.92
Magnesium oxide,	10.20
Potassium oxide,	6.85
Chlorine,	16.47

It was reported that the effect of this fertilizer on oats and peas was somewhat superior to phosphatic slag, as regards the yield of grain.

Another substitute for slag phosphate is described by Prof. P. Wagner: 100 parts of coarsely crushed phosphorite is fused with 70 parts of acid sodium sulfate; 20 parts of calcium carbonate, 22 parts of sand and 6 to 7 parts of coal; this gave a product testing 15.7 per cent. phosphoric acid, practically all of which was soluble in citric acid solution. Pot experiments were conducted on oats, grown on loam soil, by the aid of this mixture, alongside of similar experiments conducted with a superphosphate testing 17.7 per cent. water-soluble phosphoric acid and 18.9 per cent. total phosphoric acid and phosphatic slag, testing 18 per cent. citric acid soluble phosphoric and 19.9 per cent. total phosphoric acid. The fused mixture gave as quick-acting and effective results as the superphosphate, and also gave results superior to the basic slag phosphate.

During the winter of 1902 Mr. H. D. Haskins of this department made some interesting experiments in fusing Canadian apatite with a mixture of sodium and potassium carbonates. The apatite was a high-grade material, testing

31.22 per cent. phosphoric acid and 51.74 per cent. calcium oxide. His experiments were conducted as follows: 1 part of the apatite was fused with 4 parts of a mixture composed of 23 parts of sodium carbonate and 39 parts of potassium carbonate. The resulting mass was extracted with water, and showed a test of 3.68 per cent. water-soluble phosphoric acid. The residue, upon treatment with neutral citrate of ammonia, showed a test of 26.78 per cent. of reverted phosphoric acid, leaving only .76 per cent. of phosphoric acid in an insoluble form. In another experiment 1 part of the apatite was fused with 1.15 parts of the same fusing mixture, this amount of sodium and potassium carbonate being theoretically necessary to convert all of the phosphoric acid into phosphates of soda and potash. The resulting mass showed 2.56 per cent. of water-soluble phosphoric acid, 15.96 per cent. of reverted phosphoric acid and 12.70 per cent. of insoluble phosphoric acid. Mr. Haskins also made experiments to ascertain to what extent the phosphoric acid in apatite would become available if boiled with a solution of sodium and potassium carbonate. Several strengths of solution were used, but only traces of phosphoric acid were dissolved, the residue in no case showing over 1.98 per cent. available phosphoric acid. From the above observations it will appear that great fields are opened for a more extensive use of our natural phosphates when introduced in a suitable form by some fusing process.

In conclusion, we must say that the consumption of commercial fertilizers is ever on the increase, and it is a great satisfaction to feel that apparently the increased consumption of fertilizers is more than off-set by the prospective increase in natural supplies. The increased production of sulfate of ammonia from improved methods in the manufacture of coke from bituminous coal, the recent discoveries of new potash deposits in Saxony, Ger., as well as the recent reported discovery of nitrate of soda beds along the Pacific coast in the United States, all furnish pleasant reflections for the future of American agriculture.

REPORT OF THE ENTOMOLOGISTS.

C. H. FERNALD, H. T. FERNALD.

A number of different lines of investigation have been begun or continued during the year 1904, in addition to what may be termed the routine work of the division.

Experiments to determine the best treatment for the San José scale, begun at this station in 1902, have been concluded, at least for the present, as they have resulted in so thoroughly freeing the college orchard from this pest as to leave no material for further experiment. It is true that the scale is not exterminated, but it is present in such small numbers that several years must elapse before the orchard will become so reinfested as to be of any value for experimental purposes. On the other hand, it is impossible under present conditions to attempt experimental work elsewhere, and therefore this line of research is at least temporarily suspended.

A number of private preparations claiming to be useful as insecticides have been tested during the year, with varying results; but none have thus far been found which appear to be of great value. Whether it is worth while to take the large amount of time necessary for these tests, when the results, if they should ever by any chance prove valuable, would practically only produce free advertising to those manufacturing them, is certainly questionable, particularly as scarcely any of these substances are made by residents of this State.

The codling moth is now treated by spraying during the egg-laying period of this insect. In the west there are several broods of this pest each year, but in Massachusetts there seems to be much uncertainty on this point. For two years observations have been conducted to determine the

number of broods of this insect, and the proper times at which to spray the trees in order to obtain the best results. The difference in seasons is of course a factor in the determination of these points, and renders it necessary that the work be continued for a term of years before final results can be obtained.

The oyster-shell scale can easily be controlled by mild sprays if these are applied at the right times, but two years ago no one in Massachusetts seemed to know just that time. In States but a short distance south this pest has two broods, and it has been doubtful whether there were not two here also. In order to determine these questions, careful observations have been made during the last two years, and must be continued for several more in order to obtain reliable results.

For nearly three months of the year all the spare time of the entomologists was devoted to the preparation of an exhibit for the Louisiana Purchase Exposition, taking time which could otherwise have been devoted to experimental work. The nature and scope of this exhibit has been presented elsewhere, and need not be given here.

During the colder months of the year experimental work is practically impossible, and this time is made use of in putting together the results of previous investigations, and drawing conclusions from them; in classifying and arranging the materials gathered and received during the summer; in solving the more complex problems connected with cases of injury difficult to reach and control by ordinary means; and in original investigations of various kinds.

The correspondence with residents of the State requires a large amount of time. In 1903 this was less than usual, the reasons for it being considered in the last report. This year it has resumed its normal quantity, about 1,500 inquiries having been received and answered by letter, or by sending printed information on the topics concerned.

Particular effort has been made to obtain samples of the injuries caused by insects, these being often markedly characteristic, and therefore of the greatest utility in a collection so constantly referred to.

The card catalogue has now been installed in a new case, capable of holding 90,000 cards, and is in constant use; in fact, it is probably the most useful single piece of apparatus in the possession of the division. Additional cards are constantly being added as new literature is published.

Insects of the Year.

The unusually cold weather during the winter of 1903–04, together with a few sudden and marked fluctuations of the temperature, was not without its effect upon insect life, as was shown last summer, though perhaps less than might have been expected.

The San José scale was destroyed in large numbers by the winter-killing of trees, and to some extent on those which survived the winter. This demonstrates that this insect is not entirely hardy during severe winters in this latitude. Unfortunately, enough succeeded in living to produce many young during the summer, so that this insect is now somewhat more abundant than it was a year ago. It is generally distributed over the State east of the western slopes of the Connecticut valley, but seems not to have penetrated the Berkshire hills to any great extent. Spraying with the lime-sulphur mixture for this pest has been made use of by many fruit growers and others, and has proved to be an excellent method for its control.

Plant lice and root maggots have been fairly abundant this year, due perhaps to their great increase during 1903 enabling them to have so many descendants that a larger number than usual succeeded in passing the winter.

The white fly (*Aleyrodes*) in greenhouses has apparently spread in all directions, complaints of the destruction it has caused having been received from all parts of the State.

The red spider (*Tetranychus*, spp.) has also been very abundant, both in greenhouses and outside, where a characteristic brownish tinge on the leaves of affected plants has often been very noticeable.

The usual amount of correspondence about the treatment for ants in houses and on lawns, about cut-worms, wire worms, the oyster-shell and scurfy scales and the various

soft scales, indicates that these pests have been as abundant as ever, and that many people are still entirely ignorant of the appearance of their commonest insect foes.

The brown-tail moth has continued to spread over the State, and has been found in Lunenburg, Clinton and Whitman, by the State nursery inspectors. This indicates that the insect is spreading westward rapidly, and that it will be present in all parts of Massachusetts within a very few years. During the middle of July, while the moths were flying, it was noticeable that they were attracted to light, many being destroyed by flying into open arc lights on the streets, in some cases falling to the ground below the lights in such numbers as to form heaps of noticeable size.

It has usually been believed that the amount of feeding done by these insects in the fall was so slight that it could be ignored. This year, however, the caterpillars, after hatching and even after forming their tents, fed so much that where they were abundant all the foliage was skeletonized and turned brown. This was very noticeable in parts of Belmont, Arlington, Winchester and elsewhere. After the pear and apple, oaks seemed to be a favorite food for this insect, and the browning of the foliage in places was so great that newspapers called attention to "an extra brood" of this pest, and in some cases discovered that it was "a new and hitherto unknown insect" which was causing the injury.

The gypsy moth is now generally distributed over its original territory, and in one or two places has spread beyond it. In the districts where it is most abundant, the destruction it formerly caused when unchecked is again seen, and the result if no means of repression or control are taken can easily be imagined by any one who has visited these places. Local organizations in the infested districts are taking action to destroy this and the brown-tail moth, and are doing splendid work; but this should be supplemented by work on broader lines and with more power than local organizations possess, if lasting results are to be hoped for.

REPORT OF THE AGRICULTURISTS.

WM. P. BROOKS; ASSISTANTS, F. R. CHURCH, S. B. HASKELL.

The work of the agricultural department of the experiment station during the past year has in the main followed the general lines of investigation which have recently engaged attention. These for the most part are connected with questions affecting the selection and use of manures and fertilizers. To give results of value, such experiments require numerous repetitions, because of variation in product due to seasons and to conditions which we cannot fully control. In the averages of a series of years the influence of such variations is in a measure eliminated, and deductions based upon such averages will serve as a basis in farm practice.

The work of the past season has involved the care of over 220 plots in the open field, 150 closed plots and 278 pots in vegetation experiments.

Our grass garden, which includes 48 species and 7 varieties, most of them occupying 1 square rod of land, has been cared for as usual. One-half of the area in each species has been kept constantly lawn-mown, with a view to studying the probable effects of grazing; and a considerable number of species which had become mixed have been renewed, after paring and burning the old turf for the destruction of seeds and roots of weeds and other grasses.

Numerous experiments with alfalfa, both on our own grounds and on the grounds of selected farmers, are in progress. The results of this work are to be given in a bulletin. It suffices for the present to say that we have nowhere attained results so satisfactory that the extensive sowing of this crop can be advised; it must still be regarded as in the experimental stage.

A few cultures of nitrogen-assimilating bacteria, sent out by the Department of Agriculture for use with legumes, have been tried, and, so far as can be judged, with disappointing results. A bulletin descriptive of this work and the results obtained will be prepared in due time.

We have increased the scope of our work with the new and promising varieties of timothy received from Prof. A. D. Hopkins of the West Virginia Experiment Station, five years ago. Several of these are distinct improvements upon the ordinary commercial timothy, and these are being increased as rapidly as possible, for the production of seed which will later be furnished to selected farmers for trial.

Variety work with wheat, oats and barley has engaged considerable attention. Seeds of 31 varieties which for a series of years had given remarkable crops in the Dominion of Canada were kindly donated for the purpose by Dr. William Saunders, director, Experimental Farms of Canada. It was hoped that these northern-grown grains might prove valuable, but the results were disappointing. Practically all varieties were affected by rust, and the yields of most were small. The range of variation in the crops obtained was as follows: for wheat, at the rate of from 6 to 15 bushels per acre; for barley, at the rate of from 6 to 26 bushels per acre; for oats, at the rate of from 40 to 55 bushels per acre. Among the varieties of oats, the Improved Ligowa, Bavarian, Thousand $ and Wide Awake gave the best yields, — all in excess of 50 bushels. These varieties would seem to be worthy of further attention.

The work with poultry has been along the same lines as last year, the relations of food combinations to egg production being the subject under investigation.

The statement of results obtained, presented in detail in this report, does not cover all the experiments in progress.

The principal subjects of inquiry discussed, and the more important results, are as follows: —

I. — To determine the relative value of barnyard manure, nitrate of soda, sulfate of ammonia and dried blood as sources of nitrogen. The crop of this year was potatoes, and, on the basis of yield, the rank of the nitrogen-furnishing mate-

rials is as follows: barnyard manure, nitrate of soda, dried blood, sulfate of ammonia. The nitrate ranks relatively lower this year than in any previous year of the experiment except last. On the basis of increases in all the crops grown since the experiment began, as compared with the no-nitrogen plots, the materials rank as follows: nitrate of soda, 100; barnyard manure, 83.6; dried blood, 66.9; sulfate of ammonia, 56.9. In this experiment we are also testing the stubble value to succeeding crops of legumes on the no-nitrogen plots. The results of this year indicate the soy bean crop stubble to have been of little value.

II. — To determine the relative value of muriate, as compared with high-grade sulfate of potash, for field crops. The results of this year indicate the sulfate to be considerably superior to the muriate both for rhubarb and for cabbages.

III. — To determine the relative value of different potash salts for field crops. The salts under comparison are high-grade sulfate, low-grade sulfate, kainit, muriate, nitrate, carbonate and silicate. The crops of this year were cabbages, field corn and ensilage corn. The most striking results of the comparison are the relatively very low yield of the silicate of potash and the relatively high yields obtained on the nitrate and the carbonate.

IV. — To determine the relative value of phosphates used in quantities furnishing equal phosphoric acid to each plot. The crop of this year was corn. The most striking result was the very inferior yield produced on the plot where Florida soft phosphate is used. This result, in exact agreement with results with different crops in earlier years, indicates a very low degree of availability for this phosphate.

V. — *A*. Soil test with corn. The crop of this year, the sixteenth during which the experiment has continued, was excellent on all plots to which potash has been annually applied. Where muriate of potash alone has been continuously used, the yield was at the rate of about 47 bushels per acre. Where muriate of potash and dissolved boneblack have been continuously used, the yield was at the rate of 53 bushels per acre, which is the best crop produced on any combination of fertilizers, and actually exceeds the yield

on the plot where manure has been annually applied at the rate of 5 cords per acre. The experiment strikingly shows the great importance of the liberal supply of potash in fertilizers for the corn crop. *B.* Soil test with grass and clover. The nitrate of soda, whether used alone or in combination, caused a large increase in the first crop. The use of potash without lime had little effect upon the crop. Where potash has been used continuously for fifteen years, with two heavy applications of lime (in 1899 and 1904), the effect on the proportion of clover and on total yield was very marked. The most profitable crop produced by any fertilizer combination was obtained upon the plot to which dissolved bone-black and muriate of potash have been continuously applied. On the limed portion of this plot the yield is at the rate of 6,100 pounds of hay. The annual cost of the fertilizers applied to this plot has been $7.50.

VI. — To determine the relative value in crop production of a fertilizer mixture rich in potash, as compared with one representing the average of the special corn fertilizers purchasable in our markets. The result of this year is substantially equal crops under the two systems of manuring, at a cost of rather over $5 per acre less for the combination of fertilizers richer in potash.

VII. — To determine the relative value in corn production of a moderate application of manure alone, as compared with a smaller application of manure used in combination with 160 pounds of high-grade sulfate of potash per acre. The result of this year was crops under the two systems equal in amount of stover, but an average at the rate of 5 bushels of grain per acre less on the combination of manure and potash than on the manure alone. The difference in crop is not sufficient to cover the excess in cost of the larger amount of manure alone, as compared with the lesser amount of manure and potash.

VIII. — To determine the economic result of using in rotation on grass lands, the first year, barnyard manure, 8,000 pounds per acre; the second year, wood ashes, 1 ton per acre; and the third year, bone meal, 600, and muriate of potash, 200, pounds per acre. The average yield of hay

during the past season, all three systems of manuring being represented on a total area of about 9 acres, is at the rate of 8,050 pounds of hay per acre. The average for the twelve years during which the experiment has continued (1893 to 1904, inclusive) is 6,718 pounds.

IX. — To determine which is better economy, — to spread manure as hauled from the stable during the winter, or to place in a large heap to be spread in spring. This experiment was repeated in five pairs of plots. The winter application gave the better yield in three cases, the spring application in two; but the difference in the value of the crop where the spring application gave the larger yield was not sufficient to cover the difference in the cost of the two systems of handling the manure, which amounts to $4.80 per acre. The winter of 1903 and 1904 was exceptionally favorable to good results from application at that season, as conditions were such that there was no washing over the surface.

X. — To determine whether the application of nitrate of soda after the harvesting of the first crop will give a profitable increase in the rowen crop. The increases produced were considerable, but, possibly because of somewhat deficient rainfall, were not sufficient to make the application distinctly profitable.

XI. — The variety test of potatoes. Forty-nine varieties of potatoes were tested. The yield obtained from the different varieties ranged from 104 bushels of merchantable potatoes per acre for the Clinton to 319 bushels of merchantable potatoes per acre for Simmon's Model. Seven varieties gave a yield in excess of the rate of 260 bushels per acre, namely: Simmon's Model, Extra Early White Rose, Great Divide, Steuben, 1904, Mills' New Rose Beauty. These varieties are mentioned in the order of their productiveness.

XII. — Comparison of different foods and combinations of foods furnishing essential nutrients in different nutritive ratios for laying hens. The hens were supported, at a cost of about $\frac{1}{6}$ of a cent per hen daily, on mixtures of food rich in corn, as compared with a cost of about $\frac{1}{4}$ of a cent per hen daily, on mixtures of food rich in wheat. The food

cost per egg was lowest on the food mixtures containing a large proportion of corn. The combination of feeds including a considerable portion of rice and rice meal gave the most satisfactory egg yield of any combination tested, but the cost of rice is too great to make it an economical food for poultry.

I. — Manures and Fertilizers furnishing Nitrogen compared. (Field A.)

The experiments in Field A have two principal objects in view: first, to compare the efficiency (as measured by crop production) of a few standard materials which may be used on the farm as sources of nitrogen; second, to determine to what extent the introduction of a legume will render the application of nitrogen to a succeeding crop of another family unnecessary. The field includes eleven plots of one-tenth acre each. A full description of the plan followed will be found in the twelfth annual report of the Hatch Experiment Station. The materials furnishing nitrogen under comparison are barnyard manure, nitrate of soda, sulfate of ammonia and dried blood. With few and unimportant exceptions, each plot has been manured in the same way since 1890. All the plots annually receive equal and liberal amounts of materials supplying phosphoric acid and potash. Three plots in the field have had no nitrogen applied to them since 1884; the materials under comparison on the other plots in the field are applied in such quantities as to furnish nitrogen at the rate of 45 pounds per acre to each. Barnyard manure is applied to one plot, nitrate of soda to two, sulfate of ammonia to three and dried blood to two plots. The potash applied to these plots is supplied in the form of muriate to six plots, namely, 1, 3, 6, 7, 8 and 9. It is supplied in the form of low-grade sulfate to four plots, namely, 2, 4, 5 and 10. The crops grown in this experiment previous to this year in the order of their succession have been: oats, rye, soy beans, oats, soy beans, oats, soy beans, oats, oats, clover, potatoes, soy beans, potatoes, soy beans.

The crop of this year was potatoes. The variety was the Green Mountain. The seed, which was of fine quality, was grown in northern Maine. The land was plowed on May

3; manure and fertilizers were applied on the 7th, and the potatoes, which had been soaked in formalin solution for prevention of scab, were planted on May 11. The crop was thoroughly cared for throughout the season, although there was some injury from bugs, apparently due to the fact that the Paris green used for the first spraying on June 27 was impure. The vines were sprayed three times with Bordeaux mixture and Paris green: respectively, July 3, 18 and 30. There was apparently little injury from blight. The leaves on the plot to which manure was applied retained their green color considerably longer than those on the other plots. On September 10 they were estimated to be still about one-half green, while the proportion still remaining green on other plots was in general estimated to be about one-tenth to one-eighth. By September 22 the tops were dead, and the potatoes were dug between that date and the 29th. The rates of yield on the several plots and the source of nitrogen on each are shown in the following table: —

Yield of Potatoes per Acre (Bushels).

Plots.	Nitrogen Fertilizers used.	Merchantable.	Small.
0, . .	Barnyard manure, ...	236.67	41.67
1, . .	Nitrate of soda (muriate of potash), ...	190.33	36.00
2, . .	Nitrate of soda (sulfate of potash), ...	188.17	33.50
3, . .	Dried blood (muriate of potash), ...	141.33	36.00
4, . .	No nitrogen (sulfate of potash), ...	96.33	30.00
5, . .	Sulfate of ammonia (sulfate of potash), . . .	157.50	19.17
6, . .	Sulfate of ammonia (muriate of potash), . . .	102.50	13.33
7, . .	No nitrogen (muriate of potash), ...	104.33	11.50
8, . .	Sulfate of ammonia (muriate of potash), . . .	113.50	32.50
9, . .	No nitrogen (muriate of potash), ...	141.67	36.17
10, . .	Dried blood (sulfate of potash), ...	232.33	24.17

The yield on the different plots varies widely, that on the plot receiving manure being the best in the field, and standing relatively much higher as compared with the plots receiving their nitrogen in the form of a fertilizer than in any previous year. It is believed that this result must be in large measure a consequence of the fact that the application of barnyard manure tends to maintain the stock of humus in the soil, and so keeps it in a condition more favorable to productive capacity. Neither the soy bean nor the potato leaves a residue which contributes materially to the humus content of the soil, and no other crops have been grown

during the past five years. Experiments in continuous potato culture without manures in the Cornell University Experiment Station have shown in a striking manner the dependence of this crop upon the presence of a suitable proportion of organic matter in the soil.[1] The common observation that potatoes thrive exceptionally well in virgin soils and upon sod land points in the same direction.

The superiority of the yield on Plot 10 also is striking. This, in the writer's opinion, is due to the fact that the potatoes on this plot were covered by hand, while those on the other plots were covered by the use of the plow. The potatoes on this plot came up much more quickly and more vigorously than those on the others, and showed decided superiority in growth from the start.

The average yields of this year on the several fertilizers are shown in the following table: —

Fertilizers used.	Merchantable (Bushels).	Small (Bushels).
Average of the no-nitrogen plots (3),	114.11	25.89
Average of the nitrate of soda plots (2),	189.25	34.75
Average of the dried blood plots (2),	186.83	30.09
Average of the sulfate of ammonia plots (3),	124.50	21.67

As the result of all experiments previous to this year, it is found that the materials furnishing nitrogen have produced crops in the following relative amounts: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	94.00
Dried blood,	90.40
Sulfate of ammonia,	90.30
No nitrogen,	72.80

Similar averages for this year are as follows: —

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	124.30
Dried blood,	96.80
Sulfate of ammonia,	65.30
No nitrogen,	62.50

As was the case last year, the nitrate of soda stands relatively lower than in experiments of previous years, although

1 Bulletin No. 196, Cornell University Experiment Station, p. 52.

it still maintains its superiority as compared with the other fertilizers furnishing nitrogen. The barnyard manure produces a superior crop, not, it is believed, because of the superior availability of the nitrogen it contains, but, as has been suggested, because of the better physical condition of the soil produced by the humus it furnishes.

If we compare the different materials used as sources of nitrogen on the basis of increase in crop rather than on the basis of total product, they rank to date for the entire period of the experiment 1890 to 1904 as follows: —

Relative Increases in Yields (Average for the Fifteen Years).

	Per Cent.
Nitrate of soda,	100.00
Barnyard manure,	83.60
Dried blood,	66.90
Sulfate of ammonia,	59.90

These figures make the superiority of nitrate of soda as a source of fertilizer nitrogen very apparent. In view of the fact that at current prices it furnishes a pound of nitrogen at a lower cost than almost any other material, the advisability of depending chiefly upon the nitrate as a means of supplying the important element nitrogen becomes strikingly evident.

Effect of a Legume upon the Following Crop.

It is pointed out, in introducing what will be said under this topic, that the object in this experiment is not to test the effect of producing a legume which is plowed under, but simply the improvement, if any, derived from the roots and stubble the legume leaves behind when harvested. The results thus far indicate little improvement in the condition of the soil following the culture of the soy bean, with the exception of those obtained with the potato crop following soy beans in 1902. The introduction of the clover crop, on the other hand, was followed by marked improvement; and it would now appear possible that the good results with the potato crop in 1902 may have been in part at least a consequence of the unexhausted residue of the clover stubble and roots turned under in the spring of 1900. The following table, with the curve below it, makes the facts clear: —

Effect of Leguminous Crops upon the Following Crop (Pounds).

Plots (Each One-tenth Acre).	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
	Oats.	Rye.	Soy Bean.	Oats.	Soy Bean.	Oats.	Soy Bean.	Oats.
Nitrogen plots, . .	343	484	1,965	598	620	494	1,740	445
No-nitrogen plots, .	290	421	1,443	540	452	370	1,143	197

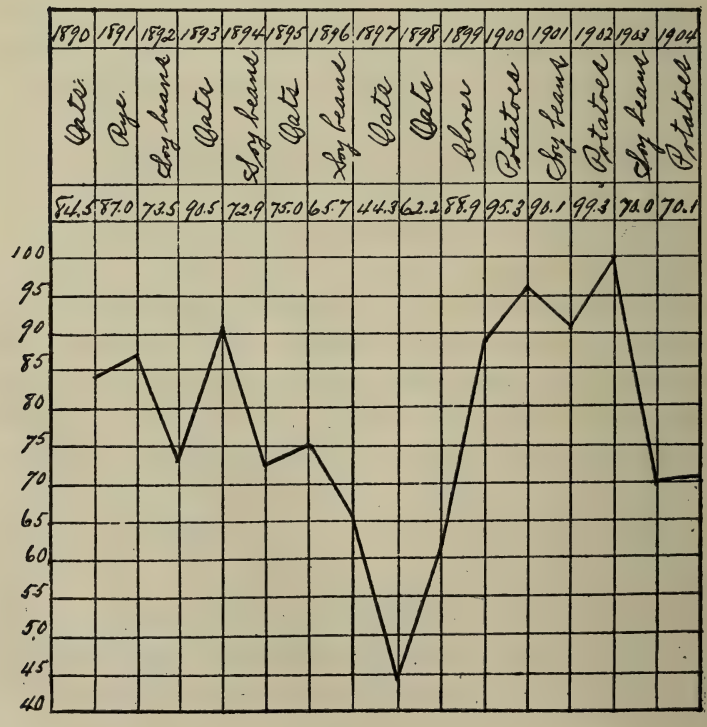
Effect of Leguminous Crops upon the Following Crop (Pounds) — Concluded.

Plots (Each One-tenth Acre).	1898.	1899.	1900.	1901.	1902.	1903.	1904.
	Oats.	Clover.	Potatoes.	Soy Bean.	Potatoes.	Soy Bean.	Potatoes.
Nitrogen plots, . .	254	413	1,316	442.2[1]	1,053.6	2,726	1,199
No-nitrogen plots, .	158	367	1,254	398.3[1]	1,046.0	1,907	840

[1] Dry beans and straw.

Curve showing Relation of Average No-nitrogen to Average Nitrogen Plots, the Latter being considered in Each Year 100.

[Per cent. average no-nitrogen to average nitrogen.]



It will be noticed that the crops following soy beans have as a rule showed little improvement which can be attributed to that crop. So long as the soy bean was the legume grown, the crops on the no-nitrogen plots continued in general to decline, as compared with the crops obtained upon the nitrogen plots. This is indicated by the fairly uniform and comparatively rapid fall in the line indicating the relative production. The introduction of clover causes a marked rise in the line indicating production, and this continues during the first three seasons following the plowing of the clover sod. The effect of the soy beans upon the crop of potatoes grown in 1902 appears to have been distinctly beneficial; but, as was stated in the fifteenth annual report, the fact that the potato crop in 1902 suffered from blight undoubtedly favored the plots where the growth was relatively feeble. In commenting upon the results obtained in 1902, I said: —

> It may be that the relative standing of the no-nitrogen plots is higher than it would have been had the crop of potatoes grown to normal maturity. It will be remembered that blight and rot prevailed to a considerable extent, and these would naturally injure the potatoes with the ranker growth more than those where the growth was less luxuriant. It does not seem, therefore, that we are justified in concluding that the after-effect of the soy beans is as useful as the relation between the figures appears to indicate.

In view, then, of the doubt as to whether the true relative capacity for product was shown in 1902, and the further fact that all other years show a general agreement in not indicating a decided benefit following the introduction of the soy bean as a crop, we seem to be justified in the conclusion that the residual fertility left behind by the soy bean is comparatively unimportant.

II. — The Relative Value of Muriate and High-grade Sulfate of Potash. (Field B.)

The object in view in this experiment is to test the relative value of muriate and high-grade sulfate of potash when used continuously upon the same soil. The experiment was begun in 1892. The potash salts were used for the period

from 1892 to 1899 inclusive, at the rate of 400 pounds per acre; since 1900 the rate of application has been 250 pounds per acre. Fine-ground bone at the rate of 600 pounds per acre has been yearly applied to all plots. The number of plots in the field at present is ten, five receiving muriate of potash, and alternating with the same number of plots which yearly receive sulfate of potash. Various crops have been grown in rotation, including potatoes, field corn, sweet corn, grasses, oats and vetch, barley and vetch, winter rye, clovers of various kinds, sugar beets, soy beans, and cabbages. Most of these crops have been grown during several years. With few exceptions, good yields have been obtained. Among the crops grown, the potatoes, clovers, cabbages and soy beans have usually done best on sulfate of potash. The yield of corn, grasses, oats, barley, vetches and sugar beets has been about equally good on the two salts, while the quality of the potatoes and sugar beets when grown on sulfate of potash has been distinctly better than on muriate of potash. Three years ago, two of the plots in this field were set to small fruits, asparagus and rhubarb, — on each plot one row each of raspberries, blackberries, asparagus and rhubarb. Aside from the crops just named, those of the past year have been cabbages on two plots and three varieties of clover, namely, Mammoth Red, Medium Red and Alsike, each on two plots. The clover was sown in the spring, and the product of the plots was considerably mixed with weeds; for this reason, the weights were not taken. There was no readily distinguishable difference in the growth of either the Medium or the Mammoth clovers that could be attributed to the difference in potash manuring. The Alsike clover upon the plot manured with sulfate of potash has made a distinctly better start than that on the muriate. Neither the asparagus, raspberries nor blackberries have yet become sufficiently established to give a full crop, and the results will not be reported in detail. The yield of asparagus was substantially equal on the two potash salts. The yield of raspberries on the muriate of potash was considerably greater than on the sulfate. Observation of the growth of the berry bushes and asparagus since they were set indicates that the rate of manuring which has been the practice on this field does not

maintain the soil in sufficiently high fertility to produce satisfactory growth on either of the combinations of fertilizers employed. During the past season, therefore, we have used nitrate of soda at the rate of 200 pounds per acre, in connection with the customary amounts of bone meal and potash, on the plots occupied by these crops.

1. Rhubarb (Sulfate v. Muriate of Potash).

The rhubarb grown in this experiment is of the Monarch variety. The growth has been vigorous and healthy. The product of this year is shown in the following table: —

Muriate v. High-grade Sulfate of Potash (Rhubarb). — Yields per Acre (Pounds).

Fertilizers used.	Stalks.	Leaves.
Muriate of potash,	8,421	11,957
Sulfate of potash,	8,559	14,286

The yield of stalks on the two plots is substantially equal, but the weight of the leaves accompanying the stalks produced on the sulfate of potash is materially greater than on the other potash salt. Whether this fact has any special significance is not at present known; but it is at least suggestive that on Field C, where, under conditions otherwise differing quite widely from those in Field B, the muriate is compared with the sulfate, a similar difference in weight of leaves as compared with stalks is found. It is, of course, evident that the results of this year do not throw any important light upon the question as to whether there is any important practical difference in the two potash salts for this crop.

2. Cabbages (Sulfate v. Muriate of Potash).

The variety of cabbages grown this year was Fottler's Brunswick Drumhead. The seed was planted in hills two feet apart and in rows three and one-half feet apart, on June 30. The plants were thinned first to two in a hill, and later, on August 16, to one. The summer and the autumn, especially the latter, averaged much below the normal temperature, and the cabbages were by no means matured on the approach of weather which compelled their harvesting. With a normal

season there is no doubt that nearly all the plants would have produced merchantable heads. Under existing conditions a very large proportion of the heads were regarded as too soft to be included in that class. The yields per acre are shown in the following table: —

Muriate v. High-grade Sulfate of Potash (Cabbages). — Yields per Acre (Pounds).

Fertilizers used.	Hard Heads.	Soft Heads.
Muriate of potash, ...	872	22,791
Sulfate of potash, ...	2,071	24,319

It will be seen that the product on the sulfate of potash is considerably superior to that on the muriate. The yield of hard heads is nearly two and one-half times as great, while the yield of soft heads also somewhat exceeds that on the muriate. As this result is in general agreement with that usually obtained heretofore with the cabbage crop, it tends to still further confirm the conclusion that it is best that the potash used for this crop be in the form of sulfate rather than muriate.

III. — Comparison of Different Potash Salts for Field Crops. (Field G.)

Field G contains 40 plots, of about one-fortieth of an acre each. The experiments in progress have for their object the determination of the relative value for field crops of all the prominent potash salts when each is used continuously upon the same land throughout a long series of years. This experiment was begun in 1898. The plots are arranged in five series of eight each. In each series one plot has received no potash since the experiment began. The potash salts under trial are as follows: kainit, high-grade sulfate of potash, low-grade sulfate of potash, muriate of potash, nitrate of potash, carbonate of potash and silicate of potash. Each is always applied in such quantity as to furnish actual potash at the rate of 165 pounds per acre. All the plots in the field are yearly fertilized with materials supplying to each equal amounts of nitrogen and phosphoric acid. For

nitrogen, nitrate of soda is applied at the rate of 250 pounds per acre, except on the plots where nitrate of potash is the source of the potash applied; here a suitable reduction in the quantity of nitrate of soda is made, on account of the nitrate nitrogen furnished by the potash salt. The principal source of phosphoric acid on these plots is acid phosphate, applied at the rate of 360 pounds per acre to all. Tankage at the rate of 270 pounds per acre is applied to all plots as a source of less immediately available nitrogen and phosphoric acid. The crops grown in this experiment in the order of succession are as follows: 1898, Medium Green soy beans; 1899, Beauty of Hebron potatoes; 1900, Fottler's Brunswick cabbage, Medium Green soy beans, Black cow pea, Wonderful cow pea; 1901, Turkish Red wheat, Medium Red clover; Rural Thoroughbred, Leaming Field, Boston Market and Eureka corn; 1902, Medium Red clover; 1903, Medium Red clover.

During the past season the crops grown in the field were as follows: cabbages on sixteen plots, two series of eight each; Sibley's Pride of the North corn on sixteen plots, two series; and Leaming Field corn for ensilage on eight plots. The season was unfavorable to full maturity for the cabbage crop, for reasons which have been alluded to in discussing results on fields B and C. For the same reasons, and also because of the excessive rains at the season of planting, the season was highly unfavorable to the corn crop. Defective germination, owing to the excessive rains, produced an uneven stand of plants in the areas devoted to corn. For the reasons indicated, it does not seem worth while to publish the results in full detail, and averages only will be given. These for the cabbages are as follows: —

Cabbages. — Average Rates of Yield per Acre (Pounds).

Potash Salt.	Hard Heads.	Soft Heads.
No potash (plots 1, 9),	10,850	22,850
Kainit (plots 2, 10),	11,100	26,150
High-grade sulfate (plots 3, 11),	10,600	25,500
Low-grade sulfate (plots 4, 12),	12,100	27,400
Muriate of potash (plots 5, 13),	11,900	26,600
Nitrate of potash (plots 6, 14),	14,800	23,100
Carbonate of potash (plots 7, 15),	16,500	23,400
Silicate of potash (plots 8, 16),	10,650	25,050

The most striking points brought out by these figures are: first, the high-grade sulfate of potash fails to show the superiority in yield to muriate which has generally been shown; second, the nitrate and carbonate of potash have given yields very materially exceeding those obtained on any of the other potash salts; third, the yield on the silicate of potash is one of the poorest in the field.

Field Corn. — Average Yields per Acre.

Potash Salt.	Sound Corn (Bushels).	Soft Corn (Bushels).	Stover (Pounds).
No potash (plots 17, 25),	15.00	17.78	3,740
Kainit (plots 18, 26),	20.25	14.00	4,300
High-grade sulfate (plots 19, 27),	19.50	13.45	4,340
Low-grade sulfate (plots 20, 28),	17.75	14.34	4,200
Muriate of potash (plots 21, 29),	20.50	14.44	4,660
Nitrate of potash (plots 22, 30),	17.00	13.45	4,020
Carbonate of potash (plots 23, 31),	17.00	15.78	4,420
Silicate of potash (plots 24, 32),	13.75	18.56	4,160

The most striking point brought out by these averages is the poor results where the silicate is the potash salt employed. Aside from this, the results with corn seem to be in general accord with those which have been usually obtained, which indicate that the different potash salts appear to have substantially similar effects upon this crop.

Ensilage Corn. — Average Yield per Acre (Pounds).

Potash Salt.	Green Fodder.	Potash Salt.	Green Fodder.
No potash (plot 33),	28,800	Muriate (plot 37),	36,800
Kainit (plot 34),	38,800	Nitrate (plot 38),	32,800
High-grade sulfate (plot 35),	34,600	Carbonate (plot 39),	30,000
Low-grade sulfate (plot 36),	36,600	Silicate (plot 40),	22,400

In the case of the ensilage, as well as field corn, the silicate of potash gives a yield much inferior to that produced by the other potash salts. That the silicate, whether with cabbages, field or ensilage corn in each of the five series of plots where it is employed, gives yields inferior to those obtained with the other potash salts, and that the yield does not in some cases equal even the yield obtained from the no-potash plot, is a fact which it seems desirable to point

out. Up to the present year the yields on silicate of potash with the different crops grown have not been markedly inferior to those obtained on other potash salts. It is impossible, in the light of our present knowledge of the conditions, to offer an explanation of the facts, although it is, of course, evident that the soil, which was originally in fair condition as regards its stock of available potash, has previous to this year been in condition to furnish a larger share of the potash needed by the crop than at present. With increasing exhaustion of natural stores of potash, the differences due to the several fertilizers used may naturally be expected to increase.

IV. — Comparison of Phosphates on the Basis of Equal Application of Phosphoric Acid.

The present is the eighth season of this experiment, which has for its object the determination as measured by crop production, of the relative availability of different materials which may be used as sources of phosphoric acid when used in such quantities as to furnish equal amounts of actual phosphoric acid to each plot, and in connection with materials which supply the other elements of plant food, especially the nitrogen and the potash, in abundance and in the same forms and in equal amounts on each of the plots. The field in which these experiments are carried on is divided into thirteen plots, of about one-eighth of an acre each. Three plots in the field, one at each end and one in the middle, have received no phosphoric acid since the experiment began. The phosphates which are employed on the other plots are as follows: apatite, South Carolina rock phosphate (fine ground), Florida soft phosphate, basic slag meal, Tennessee rock phosphate (fine ground), dissolved bone-black, raw bone meal, dissolved bone meal, steamed bone meal and acid phosphate. These phosphates are used in such quantities as to furnish actual phosphoric acid, at the rate of 96 pounds per acre. The nitrogen and potash fertilizers used supply nitrogen at the rate of 52 pounds and potash at the rate of 152 pounds per acre. With some of the crops grown (onions and cabbages) a supplementary application of quick-acting nitrogen

fertilizers has been made to all plots alike. The crops which have been grown in the field during the progress of the experiment are as follows: corn, cabbages, corn, in 1900 two crops, — oats and Hungarian grass (both for hay), onions, onions, and cabbages. With the exception of the onions and cabbages, all the crops previously grown in the field have given good yields, even on the three no-phosphate plots. The soil of the different parts of the field was not even in fertility at the start. Plot 1 was somewhat more productive than any of the others, and in general the plots tended to decline in productiveness from 1 toward 13. The crop the past season was corn. The soil of the field inclines to be heavy, and the corn crop during the prevailing cool weather of the past season suffered from poor soil conditions and low temperature, especially on plots 8, 11, 12 and 13. Observation of the growth of the crop of the preceding year (cabbages), and study of the soil conditions throughout the preceding season, had led to the conclusion that the physical and chemical conditions of the soil in the field would be improved by a heavy application of lime. The field was plowed in the fall of 1903. Freshly slacked lime to the amount of 4,675 pounds (about 2,000 pounds per acre) was applied on May 10 and plowed in on May 15. The variety of corn grown was the Leaming Field. The seed was obtained of E. E. Chester & Son, Champaign, Ill., and was of excellent quality. The rainfall was so excessive, however, that there were a few blanks in some of the plots. The crop was cut on September 19 and immediately weighed and put into the silo. The rates of the yields on the several plots are shown in the following table: —

Plots.	Fertilizers used.	Green Corn (Pounds per Acre).
1,	No phosphate,	41,000
2,	Apatite,	40,720
3,	South Carolina rock phosphate,	40,496
4,	Florida soft phosphate,	28,240
5,	Phosphatic slag,	36,440
6,	Tennessee phosphate,	32,120
7,	No phosphate,	32,344
8,	Dissolved bone-black,	30,080
9,	Raw bone,	45,800
10,	Dissolved bone meal,	41,840
11,	Steamed bone meal,	28,400
12,	Acid phosphate,	29,040
13,	No phosphate,	20,240

The point of principal significance in connection with the results appears to be the marked inferiority of the yield on the Florida soft phosphate. There was no difference in the physical conditions on this plot, as compared with those on either side, that can explain the wide difference in the amount of the product. The results of this year, then, additionally confirm the conclusions of previous years, — that this phosphate seems likely to give results which are distinctly disappointing, as compared with the claims of those interested in its production and sale. The low product on plots 8, 11 and 12 was undoubtedly in considerable measure due to the unfavorable conditions which have been referred to.

V. — Soil Tests.

In introducing what I have to say concerning soil tests, I cannot do better than to employ the language used in my last annual report, p. 244 : —

Two soil tests, both upon our own grounds and both in continuation of previous work upon the same fields, have been carried out during the past season. Fertilizers have been applied in accordance with the co-operative plan for soil tests, with one or two small exceptions. Lime and plaster have been applied to the plots calling for these fertilizers in double the usual soil test amounts. Each plot annually receives an application of the same kind or kinds of fertilizers. Such experiments are not adapted to securing the production of heavy crops. By study of the results, the effects of the different leading elements of plant food on the several crops can be determined with much accuracy.

Every fertilizer used, whether applied by itself or in connection with one or both of the other fertilizer materials, is always applied in the same quantities. Both fertilizers and manure (where the latter is introduced for purposes of comparison) are always applied broadcast after plowing, and harrowed in. The kinds and the amounts per acre are as follows: —

Nitrate of soda, 160 pounds, furnishing nitrogen.
Dissolved bone-black, 320 pounds, furnishing phosphoric acid.
Muriate of potash, 160 pounds, furnishing potash.
Land plaster, 400 pounds.
Lime, 800 pounds.
Manure, 5 cords.

A. — Soil Test with Corn (South Acre).

This acre has been used in soil tests for sixteen years, beginning in 1889. The crops for successive years have been as follows: corn, corn, oats, grass and clover, grass and clover, corn (followed by mustard as a catch crop), rye, soy beans, white mustard, corn, corn, grass and clover, grass and clover, corn, corn, and corn. Since 1889 this field has, therefore, borne eight corn crops, and during this time it has been four years in grass. The present is the third successive corn crop, these three crops following grass, which occupied the field in 1901. Last season was one of the most unfavorable for corn within the memory of our oldest men. The crop was exceedingly small, even on the land which had annually received an application of manure at the rate of 5 cords per acre. With only one exception, previous to last year, the corn crop wherever potash has been applied to the soil in this field has always been good. In 1898 the crop even where potash and other fertilizers had been used was small. This suggested the probable necessity of an addition of lime. The application of lime at the rate of 1 ton to the acre restored the productiveness of all the plots to which muriate of potash had been continuously applied. The small crop of last year, in connection with observations on the condition of the soil, led to the conclusion that lime might once more prove useful; the entire field, therefore, was given a dressing of freshly slacked lime, at the rate of 1 ton per acre. The marked increase in the crop of this year wherever potash was used indicates the correctness of the opinion that lime was needed. The plot where potash was used alone last year gave a yield at the rate of about 15.5 bushels of corn per acre; this year the product is almost three times that amount. Last year the plot to which nitrate of soda and muriate of potash are annually applied gave a yield at the rate of 16.5 bushels per acre; this year the yield is 47.8 bushels. The plot receiving dissolved bone-black and muriate of potash, which last year gave a crop of a little less than 19 bushels, this year gave a crop of rather over 53 bushels. These facts make it strikingly evident that, in connection

with fairly liberal amounts of muriate of potash, it is essential to use lime freely on many of our soils, if their productiveness is to be maintained. This field contains four plots, to which neither manure nor fertilizer of any kind has been applied during the sixteen years that the experiment has continued. These plots have now become very highly exhausted, producing crops which are practically valueless so far as the production of grain is concerned, although the nominal yield is at the rate of about 3.5 to 8 bushels per acre. The following table shows the fertilizers used on the several plots, the rate of yield, and the gain or loss per acre compared with the nothing plots: —

Corn. — South Acre Soil Test, 1904.

Plots.	Fertilizers used.	Yield per Acre.		Gain or Loss per Acre, compared with Nothing Plots.	
		Corn (Bushels, 90 Pounds).	Stover (Pounds).	Corn (Bushels, 90 Pounds).	Stover (Pounds).
1,	Nitrate of soda,	7.11	1,200	2.78	330
2,	Dissolved bone-black,	3.89	960	—.44	90
3,	Nothing,	4.33	870	-	-
4,	Muriate of potash,	46.89	3,760	42.86	2,933
5,	Lime,	2.67	820	—1.07	—37
6,	Nothing,	3.44	740	-	-
7,	Manure,	50.00	4,000	46.56	3,260
8,	Nitrate of soda and dissolved bone-black.	15.11	1,500	6.33	320
9,	Nothing,	8.78	1,180	-	-
10,	Nitrate of soda and muriate of potash.	47.67	3,560	39.71	2,440
11,	Dissolved bone-black and muriate of potash.	53.11	3,940	45.96	2,880
12,	Nothing,	6.33	1,000	-	-
13,	Plaster,	7.44	1,100	1.11	100
14,	Nitrate of soda, dissolved bone-black and muriate of potash.	47.78	3,700	41.45	2,600

It will at once be noticed that the potash is the element which determines the crop, almost to the exclusion of all others. Where potash has been used alone during sixteen years, the yield is almost as great as it is with potash and any of the other combinations. Nitrate of soda alone does

very little good. Dissolved bone-black alone gives a crop less than the average of the nothing plots. The combination of nitrate of soda and dissolved bone-black gives a very inferior crop, but wherever potash is used the crop is good. Particular attention is called, further, to the fact that the continuous use of lime alone is not beneficial; on the contrary, the yield on the plot where lime has been continuously used is the poorest in the field. Plaster used alone and continuously gives a slightly better crop, but not much in excess of the nothing plots. It may perhaps be urged that the soil of this field must be of very exceptional character; that, otherwise, the so long-continued use of one fertilizer element could not produce the results obtained. To a certain extent this criticism may be justified, and I do not call particular attention to the marked effect of the potash for the purpose of urging upon our farmers exclusive dependence upon this fertilizer, but to make more emphatic the point that our farmers in general should insist that fertilizers designed for use for the corn crop should be richer in potash than is usually the case. The results obtained in previous years on this field indicate not so much that this soil is deficient in potash, — for some crops, such as grass, for example, do well on the plots to which no potash has been applied since the beginning of the experiment, — as that the corn crop depends in a marked degree upon a liberal supply of readily available potash.

B. — Soil Test with Mixed Grass and Clover (North Acre).

The acre used in the north soil test has been kept in this experiment fifteen years, beginning in 1890. The fertilizers have been used in the same combinations and in general in the same amounts on the several plots as in the south soil test, except that during the years when onions have been grown the fertilizers have been used in double the usual quantities. Each fertilizer or combination of fertilizers has been used continuously upon the same plot. In this experiment the plots were divided transversely in 1899, and lime was applied at the rate of 1 ton to the acre to one-half of each plot. The lime was applied after plowing, and har-

rowed in. During the past season the same halves of all the plots have once more been limed, and at practically the same rate as before; but this year, as the land was in grass, the lime was applied as a top-dressing on the grass in spring. The date of application was May 13. The crops grown in this field, in the order of succession, beginning in 1890, have been: potatoes, corn, soy beans, oats, grass and clover, grass and clover, cabbages and ruta-baga turnips, potatoes, onions for four years (1898 to 1901 inclusive), potatoes, grass and clover, and grass and clover. The field was sown to grass and clover after the harvesting of potatoes in the autumn of 1902 (September 15). The rate of seeding per acre was: timothy, 18 pounds; red-top, 8 pounds; red clover, 5 pounds; and alsike clover, 4 pounds. The clover winter-killed, and accordingly additional clover seed (15 pounds) was sown on April 4, 1903.

On account of the deficiency in rainfall from the middle of April to about the 10th of June, 1903, the yields last year on all plots were very small. The yields during the past season have been much larger. They are shown in the following table: —

Grass and Clover. — North Acre Soil Test, 1904.

Plots.	Fertilizers used.	Yield per Acre, Hay.		Gain or Loss per Acre, compared with Nothing Plots.	
		Unlimed (Pounds).	Limed (Pounds).	Unlimed (Pounds).	Limed (Pounds).
1,	Nothing,	1,060	800	–	–
2,	Nitrate of soda,	1,960	1,600	1,067	880
3,	Dissolved bone-black,	1,000	680	273	40
4,	Nothing,	560	560	–	–
5,	Muriate of potash,	600	1,920	40	1,265
6,	Nitrate of soda and dissolved bone-black.	2,120	2,320	1,560	1,570
7,	Nitrate of soda and muriate of potash.	1,920	1,860	1,360	1,015
8,	Nothing,	560	940	–	–
9,	Dissolved bone-black and muriate of potash.	860	3,600	280	2,575
10,	Nitrate of soda, dissolved bone-black and muriate of potash.	2,200	4,400	1,600	3,290
11,	Plaster,	560	600	—60	—595
12,	Nothing,	640	1,280	–	–

Grass and Clover. — *North Acre Soil Test, 1904* — Concluded.

Plots.	Fertilizers used.	Yield per Acre, Rowen.		Gain or Loss per Acre, compared with Nothing Plots.	
		Unlimed (Pounds).	Limed (Pounds).	Unlimed (Pounds).	Limed (Pounds).
1,	Nothing,	140	80	–	–
2,	Nitrate of soda,	60	90	—30	7
3,	Dissolved bone-black,	60	120	30	7
4,	Nothing,	30	130	–	–
5,	Muriate of potash,	70	780	37	557
6,	Nitrate of soda and dissolved bone-black.	210	810	175	495
7,	Nitrate of soda and muriate of potash.	50	520	12	112
8,	Nothing,	40	500	–	–
9,	Dissolved bone-black and muriate of potash.	80	2,560	47	2,125
10,	Nitrate of soda, dissolved bone-black and muriate of potash.	620	2,840	595	2,470
11,	Plaster,	20	80	2	—225
12,	Nothing,	10	240	–	–

The results of this year resemble those of last year in one particular, namely, the marked increase in the first crop which follows the application of nitrate of soda; but in one important particular the results this year differ from those of 1903 in a marked degree, namely, in the very large increase on the limed portion of those plots to which muriate of potash has been annually applied. In commenting upon the results of last year, I said: —

Much evidence is afforded by a study of the relative proportions of the different species on the different plots and on the limed and unlimed portions of the several plots, that the soil in some parts of this field is once more becoming acid.

The principal ground on which this statement was based was the comparative absence of clover, even on the limed portion of such plots as had been supplied annually with potash. This relative absence of clover last year was doubtless in part due to the unfavorable climatic conditions; but the widely different results of this year indicate that the lime applied this season proved distinctly and largely beneficial.

It is desired to call particular attention to the yield both of hay and of rowen on the limed portion of Plot 9. This

plot, it should be understood, has not received an application of anything furnishing nitrogen during the fifteen years that the experiment has continued; and yet on the limed portion of this plot we this year have a yield of hay at the rate of 3,600 pounds and a yield of rowen at the rate of 2,560 pounds per acre, — a total of rather over 3 tons, at a fertilizer cost at the rate of $6.50 per acre. Allowing for an application of lime at the rate of a ton once in eight years, the annual cost of the materials applied to this plot amounts to about $7.50 per acre. The yields obtained at this very low cost indicate in a most striking manner the possibilities in the production of clover hay on soils naturally suited to clovers, without the use of the expensive nitrogen manures or fertilizers.

It is of especial interest to compare the yields of Plot 10 with those on Plot 9. Plot 10 has annually received nitrate of soda, in addition to the same amounts of dissolved bone-black and muriate of potash as are used on Plot 9. The result is a fair hay crop, even on the part of the plot where lime has not been used. Here, however, as on Plot 9, the yield is greatly increased by the application of lime, and we have a total in the two crops of the year at the rate of 7,240 pounds per acre. This exceeds the yield of the two crops on Plot 9 at the rate of a little more than a thousand pounds per acre. This increase is produced as the result of an application at the rate of 160 pounds of nitrate of soda. Such an application would cost about $4, and the increase is therefore produced at a moderate profit.

As in previous years, the relative proportion of the different species (red-top, timothy and clovers) on the several plots has been carefully studied. The most important points noted are as follows: first, the use of nitrate of soda increases the proportion of red-top; second, potash increases the proportion of clover in a marked degree, and this influence is enormously increased on the limed portion of the plots.

It will be seen, by reference to the table showing how the fertilizers are applied, that Plot 6, which receives an application of nitrate of soda and dissolved bone-black annually, lies between two plots (5 and 7) each of which annually receives an application of potash. During the past season,

and to some slight extent in previous seasons, it has been noticed that the growth of the crops on the edges of Plot 6, although it is separated from 5 and 7 by strips 3½ feet in width which have not received any fertilizer since the experiment began, shows plainly the influence of the potash applied to the neighboring plots, which has apparently diffused through the intervening 3½ feet strips, and is now beginning to affect the growth of the crops on Plot 6. During the past season there has been a little fringe of clover on each edge of Plot 6; this, however, has not been sufficient in amount to materially affect the yield on this plot, which, as will be seen, showed but little increase in the amount of rowen, which best measures the proportion of clover. The figures, however, for this plot are undoubtedly to some small degree misleading. The nitrate and the dissolved bone-black alone would produce little or no clover; they have, however, produced a fairly large crop of hay, about equally good on the unlimed and limed portions of the plot. This result is doubtless to be ascribed mainly to the effect of nitrate of soda in stimulating the growth of the grasses.

The relatively small increase on the limed portion of Plot 7, where nitrate of soda and muriate of potash are used together, appears to be due to the fact referred to in my last annual report, — that, where these two fertilizers are used together, soil effects very unfavorable to the growth of clover follow. It is believed that, to correct this unfavorable influence of these chemicals, lime must be used in very large amounts.

VI. — Special Corn Fertilizer *v.* Fertilizer richer in Potash.

It may be remembered that on this acre we are endeavoring to throw light upon the question as to the proper composition of fertilizers used alone for the corn crop. This experiment began in 1891. The crop from 1891 to 1896 inclusive was corn; in 1897 and 1898 the crop was mixed grass and clover; in 1899 and 1900 it was corn; in 1901 and 1902, grass and clover; in 1903 and 1904, corn. A statement of the results to date will be found in preceding an-

nual reports. The object in view is to test the question as to whether the special corn fertilizers offered in our markets are of such composition as is best suited for the production of corn in rotation with mixed grass and clover. The field used in the experiment contains one acre, and is divided into four equal plots. Plots 1 and 3 have yearly received an application of mixed fertilizers, furnishing the same amount of nitrogen, phosphoric acid and potash as would be furnished by 1,800 pounds of fertilizer of the composition of the average of the special corn fertilizers analyzed at this station. This average has changed but little during recent years, and in 1899, since which date we have made no change in the kinds and amounts of fertilizers used, was as follows : —

	Per Cent.
Nitrogen,	2.37
Phosphoric acid,	10.00
Potash,	4.30

The various fertilizers offered in 1899 differed widely in composition. The extent of the variation is shown in the following table : —

	Per Cent.
Nitrogen,	1.5– 3.7
Phosphoric acid,	9.0–13.0
Potash,	1.5– 9.5

The fertilizers used on plots 2 and 4 are substantially the same in kind and amount as recommended in Bulletin No. 58 for corn on soils poor in organic matter. The essential difference in composition between the fertilizer mixtures under comparison is that that used on plots 2 and 4 is richer in potash and much poorer in phosphoric acid than the mixture representing the average market corn fertilizers. The fertilizers applied to the several plots are shown below : —

Fertilizers used.	Plots 1 and 3 (Pounds Each).	Plots 2 and 4 (Pounds Each).
Nitrate of soda,	30.0	50.0
Dried blood,	30.0	–
Dry ground fish,	37.5	50.0
Acid phosphate,	273.0	50.0
Muriate of potash,	37.5	62.5

The crop of the past two seasons has been corn, the crop of 1903 being the first to follow mixed grass and clover, which occupied the land in 1901 and 1902. The season of 1904, while too low in average temperature for the best growth of corn, was distinctly more favorable to the crop than 1903. The following tables show the yields on the several plots and the averages for the two systems of manuring: —

Yields of Corn, 1904.

Plots.	Good (Bushels).	Soft (Bushels).	Stover (Pounds).
Plot 1 (lesser potash),	59.25	7.78	10,640
Plot 2 (richer in potash),	57.50	9.33	9,208
Plot 3 (lesser potash),	57.75	7.79	8,280
Plot 4 (richer in potash),	55.25	13.56	9,660

Average Yields per Acre.

Plots.	Good (Bushels).	Soft (Bushels).	Stover (Pounds).
Plots 1 and 3 (lesser potash),	58.50	7.78	9,460
Plots 2 and 4 (richer in potash),	56.37	11.45	9,434

It will be seen that the yields under the two systems of fertilization were substantially equal, although the grain on plots 1 and 3 was better ripened than on the other plots. During the early part of the season the growth of the corn on plots 1 and 3 was materially better than on plots 2 and 4; the plants showed a better color and were of larger size. This difference showed itself very early in the season. On July 6, it was judged that the plants on plots 1 and 3 averaged one and one-half times the height of the plants on the other plots, and the difference in the growth on that date was judged to be considerably less than at an earlier period. As the season advanced, the corn on plots 2 and 4 steadily gained in condition and size, as compared with that on plots 1 and 3; and by the end of the season, as the harvest showed, the initial superiority on plots 1 and 3 had entirely disappeared. At present we are not in a position to state

to what cause the superior growth on plots 1 and 3 early in the season was due; but it appears probable that the cause was the stimulative effect of the excess of phosphoric acid, which, as has been repeatedly shown, when used in liberal amounts exercises a marked effect in hastening maturity.

At present prices for fertilizer materials, the fertilizers used on plots 1 and 3 cost, laid down in Amherst, at the rate of $19.25 per acre; those used on plots 2 and 4 cost at the rate of $14.20 per acre. The fertilizer combination richer in potash, therefore, costs a little more than $5 per acre less than the combination representing average corn fertilizers. It is significant that at this lower cost we have a corn crop equal to that produced at the higher figure. Last year, when the corn crop on all plots was very poor, the yield on plots 1 and 3 was distinctly better than on plots 2 and 4; but, with that exception, the average results to date show corn crops substantially equal on the two fertilizer combinations, while whenever the land is put into mixed grass and clover, the fertilizer combination richer in potash gives crops materially larger and of better quality than the combination richer in phosphoric acid. The advantage to date, therefore, is most decidedly in favor of the fertilizer combination containing the more potash; and fertilizer manufacturers are urged to increase the proportion of this element in corn fertilizers, and farmers on their part should insist on such increase.

VII. — Manure Alone *v.* Manure and Potash.

These experiments, which have for their object to show the relative value as indicated by crop production of an average application of manure used alone, as compared with a smaller application of manure used in connection with a potash salt, were begun in 1890. The field used is level, and the soil of comparatively even quality. It is divided into four quarter-acre plots. The crop grown during the years 1890 to 1896, 1899 and 1900, 1903 and during the past season, has been corn. In 1897 and 1898, and again in 1901 and 1902, the crop was mixed grass and clover. Where manure is used alone, it is applied at the rate of 6

cords per acre. Where manure is used with potash, the rates of application are: manure, 4 cords; high-grade sulfate of potash, 160 pounds per acre. Manure alone is applied to plots 1 and 3; the lesser quantity of manure and high-grade sulfate of potash to plots 2 and 4. Estimating the manure alone as costing $5 per cord, applied to the land, the money difference in the cost of materials applied is at the rate of $5.30 per acre, the manure and potash costing that amount less than the larger quantity of manure alone. The tables show the rates of yield on the several plots, and the averages, under the two systems of manuring.

Yield of Corn, 1904.

Plots.	Corn (Bushels).	Stover (Pounds).
Plot 1 (manure alone),	68.25	5,840
Plot 2 (manure and potash),	66.25	5,280
Plot 3 (manure alone),	66.50	4,280
Plot 4 (manure and potash),	58.25	4,840

Average Yields per Acre.

Plots.	Corn (Bushels).	Stover (Pounds).
Plots 1 and 3 (manure alone),	67.37	5,060
Plots 2 and 4 (manure and potash),	62.25	5,060

The averages made show an equal amount of stover produced under the two systems of manuring, and slightly more than 5 bushels of corn per acre less on the combination of manure and potash than on the larger quantity of manure alone. This difference in yield is not sufficient to pay the added cost of the larger quantity of manure applied to plots 1 and 3; but, since manure is an article of home production on most farms where corn is grown, not much importance would be attached to this point by the average farmer. The corn crops produced under the two systems of manuring previous to this year have been substantially equal. The inferiority in yield this year is of consequence only on Plot 4; and it is suspected that accidental variation in conditions determined the smaller product on this plot, rather than the

difference in the system of manuring. We know that the plants in the field, on account of imperfect germination due to the unfavorable weather which preceded and followed planting, were not as thick as is desirable. The fact, however, that the yield of stover on Plot 4 is greater than that on Plot 3, renders it exceedingly doubtful whether the cause of the relatively small yield of corn on Plot 4 was the greater proportion of unoccupied space.

VIII. — Experiment in Manuring Grass Land.

The report which is to be made concerning results in this experiment is best introduced by quoting from my sixteenth annual report: —

In this experiment, which has continued since 1893, the purpose is to test a system of using manures in rotation for the production of grass. The area used in the experiment is about nine acres. It is divided into three approximately equal plots. The plan is to apply to each plot one year barnyard manure, the next year wood ashes, and the third year fine ground bone and muriate of potash. As we have three plots, the system of manuring has been so arranged that every year we have a plot illustrating the results of each of the applications under trial. The rates at which the several manures are employed are as follows: barnyard manure, 8 tons; wood ashes, 1 ton; ground bone, 600 pounds and muriate of potash, 200 pounds, per acre. The manure is always applied in the fall, ashes and the bone and potash in early spring.

The past season was exceptionally favorable for the production of a heavy yield of hay, but a relative deficiency in rainfall during the period occupied by the growth of the rowen crop was doubtless the principal reason for the falling off in the yield of rowen, as compared with that produced in the season of 1903. The yields of hay and rowen and the total yields for each system of manuring were at the following rates per acre: —

Fertilizers used.	Hay (Pounds).	Rowen (Pounds).	Totals (Pounds).
Barnyard manure,	7,068	2,147	9,215
Bone and potash,	6,024	2,030	8,054
Wood ashes,	4,866	2,064	6,930

The average total yield of the entire area for this year is 8,050 pounds. The average for the entire period during which the experiment has continued (1893 to 1903 inclusive) is 6,597 pounds. The average to date is 6,718 pounds. The average yield when top-dressed with manure has been 7,026 pounds; when top-dressed with wood ashes, 6,304 pounds; when top-dressed with bone and potash, 6,686 pounds. The yields for the past year, it will be noticed, are considerably above the averages for the entire period.

Different Seed Mixtures compared.

In my last annual report[1] will be found a description of the variation in the seed mixtures used on different portions of two plots in this field (1 and 2). In one of these seed mixtures timothy is the most prominent species; in the other, meadow and tall Fescue are prominent; and these different mixtures may be spoken of respectively as the timothy mixture and the Fescue mixture. The timothy mixture is substantially the same as that in general use among farmers, including timothy, red-top, common red clover and alsike clover. The other mixture includes small quantities of all of these species, and in addition Kentucky blue-grass and the two Fescues named. In my last report the statement is made that it is believed that the Fescues will hold the ground more tenaciously than the timothy. The yields last year were materially greater on the portions of the plots occupied by the timothy mixture. The rates of yield on the two mixtures for the past season are as follows: —

	Yield per Acre (Pounds).	
	Hay.	Rowen.
Plot 1, Timothy mixture,	6,229	2,101
Plot 1, Fescue mixture,	5,769	2,121
Plot 2, Timothy mixture,	5,541	2,129
Plot 2, Fescue mixture,	5,896	2,597

The differences this year are materially less than last, and on Plot 2 the Fescue mixture has given the larger yield.

[1] Sixteenth annual report, Hatch Experiment Station, pp. 145, 146.

The timothy has not yet been displaced by other species to any noticeable extent, but the poorer showing of the mixture in which it is prominent this year as compared with last possibly indicates that the belief that the Fescue mixture would ultimately prove the better of the two will be justified by the results obtained.

IX. — Experiment in the Application of Manure.

This experiment is designed to ascertain whether it is economically good policy to spread manure during the late fall and winter, and allow it to remain on the surface until spring before plowing under. This system in our experiment is compared with the plan of hauling manure to the field during the winter, and putting it into large heaps. To insure even quality of the manure used in the two systems, it is our practice to manure two plots at one time, putting the loads of manure as hauled to the field alternately upon the two, in the one case spreading, but in the other putting a sufficient number of loads to provide for the entire plot into one large heap. We are using in this experiment five large plots, each of which is subdivided into two subplots. For one of these subplots the manure is spread when hauled out, for the other it is put into a large heap. The area of these subplots is about one quarter of an acre, and to each the amount of manure applied is 11,096 pounds. The manure from well-fed milch cows is used upon eight subplots, and horse manure on two. The manure used in this experiment is applied at different dates during the winter, our practice being to allow the manure to accumulate in the pits from which it is taken until there is a sufficient quantity for at least two subplots. The condition of the soil at the time of application and the nature of the weather which follows must necessarily differ in the different experiments; and these differences, together with the difference in the dates of application above referred to, no doubt in a measure account for the variation in the results of the two systems noticed on the different plots.

The crop in this field last year was soy beans. After the beans were harvested, winter rye was sown as a cover crop.

The date of sowing was necessarily late, and the rye went into the winter very small. There was no injury, however, from winter-killing, and at the date of plowing last spring, May 14, this crop had made considerable growth. The crop of the past season was a mixed growth of Sibley's Pride of the North corn and Medium Green soy beans for ensilage. The corn, on account of seasonal peculiarities several times alluded to in this report, germinated somewhat imperfectly, and there was some damage due to pulling of the young plants by crows. The proportion of corn to beans, therefore, was somewhat lower than is desirable. The date of planting was June 13 and 14, the work having been impossible earlier, on account of the wet condition of the soil. Taking into consideration the condition of the soil at the time of planting and the relatively low temperature of the summer, the crop was fairly satisfactory; but it was undoubtedly unfavorably affected in places because of faulty soil conditions. It was judged that these conditions most seriously affected the several pairs of plots directly compared in the following table as follows: in Plot 1, on the south half; in Plot 2, on the north half; in Plot 3, on the south half; in Plot 4, on the south half; and in Plot 5, on the south half. These facts should be kept in mind in interpreting the results. The rates of yield per acre and the relative standing of the several plots are shown in the following table: —

Actual and Relative Yields of Green Forage. — Corn and Soy Beans.

Plots.	Actual Yields (Rates per Acre, Pounds).		Relative Yields (Per Cent.).	
	North Half, Winter Application.	South Half, Spring Application.	North Half, Winter Application.	South Half, Spring Application.
Plot 1, ...	26,622	24,549	100	92.2
Plot 2, ...	20,548	22,062	100	107.4
Plot 3, ...	15,375	20,007	100	130.1
Plot 4, ...	22,167	20,595	100	92.9
Plot 5, ...	22,959	22,325	100	97.2

Attention is called to the fact that the differences this year, with one exception, are not very large, and that with

the single exception alluded to it is the half-plot on which the soil conditions were least favorable which gives the smaller yield. The winter of 1903 and 1904 must be regarded as having been on the whole favorable to winter application. The ground, it is true, was deeply frozen before the coming of snow, but the winter was severely and continuously cold. There was a noticeable absence of winter rains and thaws, during which water washes in large quantities over the surface. In estimating the significance of the result, it must be kept in mind that it costs more to put manure first into a large heap and then in spring to take it from this heap and spread it, than it does to spread during the winter at the time the manure is hauled from the stable. The money difference in the cost of handling manure in the two ways, as shown by our experience, amounts to about $4.80 per acre. The difference in the value of the crops in favor of spring application is scarcely sufficient to cover this added cost, even on Plot 3, where such difference was greatest; and, although the unfavorable soil conditions above referred to doubtless lowered the product on that special plot where the manure was applied in the spring in three instances, plots 1, 4 and 5, it seems highly improbable that, even with equality of conditions, the gain from spring application on these plots would have given a degree of superiority sufficient to cover the added cost.

Previous reports have tended to show spring application to be advisable on this field, which has a considerable slope; and so I still believe it will in the long run prove to be. The exceptional character of the winter of 1903 and 1904 is a sufficient explanation of the difference in average results.

X. — Nitrate of Soda for Rowen.

This experiment is an effort to determine whether an application of nitrate of soda after the harvesting of the first crop will give an increase in rowen sufficient to cover the cost. The field where the experiment has been a number of times repeated is a mixed timothy and clover sod. It is divided into eight plots of like area, these plots being numbered 1 to 8 and each including about three-eighths of

an acre. Nitrate of soda at the rate of 150 pounds per acre is applied to plots 2 and 4, while the application on Plot 6 is 200 pounds, and on Plot 8 250 pounds. To the remaining plots no nitrate is applied. The first crop of hay in this field was housed on July 14. The rate of yield was 6,314 pounds per acre. When this experiment has been tried in previous years, it has been found a matter of considerable difficulty to spread the relatively small amounts of nitrate of soda used evenly; and, as a means of obviating this difficulty, the nitrate used on each plot during the past season was mixed with basic slag meal. The amount of slag meal applied was 137½ pounds per plot, and the slag meal was applied to the plots receiving no nitrate as well as to the others, and on all in equal amounts. The mixture of slag and nitrate remained dry, and its even application was relatively easy. At the rates used, the nitrate and slag were mixed in proportions varying from about one nitrate to three slag to about one nitrate to two slag. Even with the higher proportions of nitrate to slag, the mixture remained dry and in convenient form for application. The rates of yields on the several plots are shown in the following table: —

Nitrate of Soda for Rowen. — Yields per Acre (Pounds).

[Basic slag meal at the rate of 137½ pounds per plot.]

Plots.	Nitrate used (Rates per Acre).	Yield.
Plot 1,	No nitrate,	716
Plot 2,	Nitrate of soda, 150 pounds,	1,341
Plot 3,	No nitrate,	990
Plot 4,	Nitrate of soda, 150 pounds,	1,432
Plot 5,	No nitrate,	853
Plot 6,	Nitrate of soda, 200 pounds,	1,234
Plot 7,	No nitrate,	1,021
Plot 8,	Nitrate of soda, 250 pounds,	1,932

In the effort to determine whether the application of nitrate is profitable, the yield wherever it has been applied has been compared either with the yield of the nearest plot, or, in cases where it is possible, with the average yield of

the two plots between which the plot under consideration lies to which no nitrate was applied. On this basis, the average increase due to application of 150 pounds of nitrate of soda was 499 pounds; the use of 200 pounds of nitrate of soda gave an apparent increase of 297 pounds; while the application of 250 pounds of nitrate of soda gave an apparent increase of 911 pounds. The weather during the period of growth of the rowen crop was too dry for the best results. At the rates of increase shown, the application would be hardly profitable.

XI. — Variety Test, Potatoes.

During the past season we have carried out the second year's trial of forty-nine different varieties of potatoes, including practically all of those of recent origin advertised in prominent seed catalogues up to the spring of 1903, as well as two or three old standard sorts for comparison. The seed used this year was grown from the original stock of each of the varieties on our own grounds in the season of 1903. The seed of all varieties was carefully preserved during the winter under precisely similar conditions. In preparation for planting, the tubers were treated with formalin for prevention of scab, in the customary manner. After removal from the formalin solution, they were spread in a thin layer in an airy room April 30, where they were allowed to lie until the 17th of May, when the tubers were cut into pieces of about two or three eyes each, and planted. The soil used in this experiment is a medium loam. It produced a corn crop in the season of 1903, and mixed grass and clover seeds were sown in the standing corn. Neither grass nor clover had made much growth when the field was plowed on May 3 in preparation for the potatoes. The field received an application of barnyard manure at the rate of 4½ cords per acre, and fertilizers at the following rates: —

	Pounds.
Nitrate of soda,	175
Dried blood,	225
Acid phosphate,	625
Dry ground fish,	400
High-grade sulfate of potash,	350

Both manure and fertilizers were spread evenly after plowing, and harrowed in. The varieties grown and the rate of yield of each are shown in the following table: —

Variety Test Potatoes. — Rates of Yield per Acre.

VARIETY.	Merchantable (Bushels).	Small (Bushels).
Admiral Foote,	208	25
Beauty of Hebron (home grown),	204	35
Beauty of Hebron (Maine seed),	167	21
Clinton,	104	10
Crine's Lightning,	210	7
Daughter of Early Rose,	221	8
Daybreak,	167	29
Early May,	161	33
Early Nancy,	225	27
Early Norwood,	215	40
Early Rose,	256	29
Ensign Bagley,	192	38
Eureka Extra Early,	196	38
Extra Early Pioneer,	204	42
Extra Early White Rose,	294	6
Gem of Aroostook,	248	42
Governor Yates,	259	29
Great Divide,	273	31
Hamilton's Early,	225	8
I. X. L.,	256	38
John Bull,	217	8
Junior Pride,	171	38
Kaiser Krone,	154	50
King of Michigan,	197	60
King of Ohio,	125	29
Market Prize,	256	8
Maxima,	263	31
Million Dollar,	225	13
Mills' New Rose Beauty,	263	15
Milwaukee,	165	25
New Early Wisconsin,	183	33
New Surprise,	204	29
1904,	263	27
Nome,	204	13
Nott's Peachblow,	192	14

Variety Test Potatoes. — Rates of Yield per Acre — Concluded.

VARIETY.	Merchantable (Bushels).	Small (Bushels).
Pat's Choice,	217	11
Peck's Early,	223	10
Prince Henry,	206	17
Red River Triumph,	208	14
Red River White Ohio,	156	31
Sensation,	248	14
Simmon's Model,	319	25
Snowflake, Jr.,	252	8
Steuben,	268	38
Sweet Home,	140	48
Van Ornam's Earliest,	197	17
Vornehm,	185	33
White Ohio,	146	27

The growth of practically all varieties was normal and healthy. The vines were sprayed twice with Bordeaux mixture for prevention of blight and rot. The treatment was successful, and the yield of most varieties was good. One variety, Simmon's Model, gave a yield exceeding 300 bushels per acre. The smallest yield is that given by the Clinton, — 104 bushels of merchantable tubers per acre. Six varieties, mentioned in the order of their productiveness, gave yields of merchantable tubers at rates between 260 and 300 bushels per acre, viz.: Extra Early White Rose, Great Divide, Steuben, Maxima, 1904, Mills' New Rose Beauty. The Beauty of Hebron, which in previous variety tests has given yields almost as large as any under trial, takes a lower rank as the result of the test of last season.

XII. — Poultry Experiments.

The poultry experiments of the past season have followed along precisely similar lines to those followed last year. We are making an effort to throw light on the question as to the proper selection of feeds for laying fowls.

1. In the experiment comparing wheat with corn, animal meal being the source of the animal food used, the following

results were obtained: for the first period, February 3 to May 17, the wheat ration produced eggs at the average rate of .4333 per hen day; the corn ration at the rate of .3837 per hen day; in other words, 100 hens would have laid per day on the wheat ration 43⅓ eggs, and on the corn ration practically 38⅓ eggs per day. For the second period, May 17 to September 30, the wheat ration produced an average of .1911 eggs per hen day, the corn ration .2067 eggs per hen day; or, in other words, 100 hens would have laid on the wheat ration about 19⅒ eggs and on the corn ration 20⅔ eggs per day. The average food cost per egg produced was for the wheat ration .611 cents, for the corn ration .505 cents for the first period; while for the second period the cost per egg on the wheat ration was 1.657 cents, and on the corn ration 1.315 cents. The gross cost of the food on the wheat ration varied from about .24 to .30 cents per day for each fowl, while on the corn ration the cost varied from about .17½ to about .26 cents per day. The yield of eggs during the second period was very small. The small average product is to be attributed largely to the fact that the period was continued beyond the date when the hens began to molt. The 20 hens on the wheat ration laid only 82 eggs during the last two months of the experiment, while those on the corn ration laid only 158 eggs during the same time.

2. In the experiment comparing wheat with corn, with milk albumin as the source of animal food and with corn oil added as a source of fat, the egg product was as follows: for the first period, February 3 to May 17, the wheat ration produced eggs at the average rate of .463 eggs per hen day, the corn ration .4324 eggs per hen day; or, in other words, 100 hens would have laid on the wheat ration practically 46⅓ eggs per day, and on the corn ration 43¼ eggs per day. For the second period the wheat ration gave an average of .3109 eggs per hen day, the corn ration .3017 eggs per hen day; or, in other words, respectively for the wheat ration an average of 31 eggs per 100 hens daily, and for the corn an average of 30⅙ eggs. The food cost of the eggs in this experiment was as follows: for the wheat ration during the

first period .5471 cents per egg, for the second period 1.3406 cents; for the corn ration the figures were for the first period .3932 cents per egg, and for the second .918 cents. The cost of feeding the hens was: for the wheat ration during the first period at the rate of .227 cents per day, for the second period, .39 cents; for the corn ration the cost of food for the first period was .155 cents per hen daily, for the second period .263 cents. The egg yield in this as in the other experiment is very low for the second period. The causes are similar to those which have been pointed out under 1.

3. In the experiment comparing wheat with rice, and with milk albumin as the source of animal food, the results have been as follows: for the first period the egg production was: for the wheat ration .3813 per hen day, for the rice ration .4077; or, in other words, from 100 hens daily respectively about 38⅛ and 40¾ eggs per day. For the second period the averages were on the wheat ration .2244 eggs per hen day, and on the rice ration .3018 eggs per hen day; or from 100 hens daily respectively nearly 22½ and a little more than 30⅙ eggs per day. The food cost of the eggs has been as follows: for the wheat ration for the first period .6976 cents, for the second period 1.59 cents; for the rice ration for the first period 1.1863 cents, for the second period 2.379 cents. The cost of keeping the hens has been as follows: for the wheat ration during the first period .2414 cents per hen daily, for the second period .34 cents; for the rice ration for the first period .4442 cents per hen daily, and for the second period .7003 cents.

The ration including rice this year as last has given one of the most satisfactory egg products obtained. The high cost of this food at the present time seems to preclude its becoming a question of much practical importance whether rice is well or ill suited as a food for egg production. We have introduced it in our experiments as a means of testing the question as to whether fat is an important constituent in the food for laying hens, rice being lower in fat than any other grain we can obtain. The large egg product where rice is prominent among the foods used seems to indicate

that fat is less important than has been judged as the result of some of our earlier experiments. Among the various grains, cleaned rice, as put upon our markets, contains least fiber, and rice is known to be the most digestible of all the grains. It is perhaps these pecularities of this grain which account for its apparent good effect on the egg product.

The nutritive ratios in the food combinations used in the different experiments of the past year have been as follows : —

For the rations where wheat is compared with corn with animal meal as the source of animal food : for the wheat ration, 1 : 4.46 ; for the corn ration, 1 : 6.42.

For the experiment in which wheat is compared with corn, milk albumin being the source of animal food : for the wheat ration, 1 : 4.43 ; for the corn ration, 1 : 6.18.

In the experiment in which wheat and rice have been compared : for the wheat ration, 1 : 4.35 ; for the rice ration, 1 : 6.2.

Our experiments throw relatively little light upon the question as to the proper nutritive ratio in feeding for eggs. The factors affecting the egg yield must be numerous, and others than the question of the nutritive ratio in the foods given to the fowls must often determine the results. The fact that we have the most satisfactory egg yield obtained during the past year on the rice ration, with a nutritive ratio of 1 : 6.20, does not at least seem to support the opinion that the nutritive ratio in feeding for eggs should be narrow.

REPORT OF THE HORTICULTURISTS.

F. A. WAUGH; GEO. O. GREENE, ASSISTANT.

The work of this division has followed the plans outlined in the reports of 1902 and 1903. The following subjects are ready for discussion, and reports are made herewith: —

I. Report on plums.
II. Experiments in pruning peach trees.
III. Growing chrysanthemums for a retail trade.

Report on Plums.

The horticultural department has a fairly large collection of plums. A number of these are represented by several trees each, enough to determine their commercial quality. The plum crop of 1904 was unusually good; it was abundant in quantity, and generally of good quality. This was true of all classes of plums, practically every variety on the grounds bearing a normal crop. This furnished an excellent opportunity for making observations on the different varieties. The notes follow below. It has been thought best to omit any extended description of these varieties for the present. This form of report is justified by the fact that nearly all the varieties mentioned are old and well-known sorts. The notes this year are valuable chiefly in showing the behavior of these well-known varieties in this particular locality. The problem of local adaption of varieties is nowadays considered to be one of the most important in horticulture, and in no class of fruits or vegetables are these local adaptations more complicated than with plums. The varieties below are classified as nearly as possible into the more commonly accepted pomological groups.

DOMESTICAS.

Agen (*Prune d'Agen*). — Tree unhealthy and a poor grower, moderately productive, an irregular cropper; fruit very good, but not so bright nor large as in some localities.

Bradshaw. — This is one of the best plums of its class, and, indeed, one of the best market and home-use plums of any class on our grounds. We have about twenty young trees in bearing which gave a good crop in 1904. The tree is a strong somewhat upright grower, does not come early into bearing, but bears well after reaching an age of eight to ten years. The fruit buds do not seem to be tender here, as they are in some localities. The fruit is large, smooth, bright and of excellent quality.

Bryanstone. — Tree an irregular and slow grower, late and irregular in bearing; not reliable. Fruit small to medium in size; of good quality.

Clyman. — Represented only by a single specimen, which bears sparsely and does not seem to be of any value.

Dame Aubert (*Yellow Egg, Magnum Bonum*). — Tree rather upright in growth, fairly strong and hardy, but does not bear heavily. Fruit large and fine, but very subject to rot.

Damsons. — Several varieties of Damsons are included in our collection, among which the French Damson seems to be the best; this bears fairly well, but by no means as abundantly as in some sections.

Diamond. — A fairly strong, healthy tree, coming late into bearing, and yielding uncertain crops here.

Englebert (*Prince Englebert*). — Tree upright, strong and hardy; does not come early into bearing, but yields good crops after reaching ten years of age. Fruit of medium size and fair quality.

Fellenburg (*Italian Prune*). — Tree round-topped, bushy, with spreading irregular branches; does not bear until eight or ten years of age, and then not very heavily. Fruit of good quality. This variety does not rank so highly as a market plum as in western New York or Michigan.

Field. — Tree seems to be not very strong and healthy, but bears fairly well. Fruit of excellent quality. This is a promising, medium early plum.

Giant Prune. — Our trees are young and poor, and have borne only a few samples. The fruit is large and attractive. This variety is worthy of further test.

Gueii. — Tree rather a bushy grower; fairly productive. Fruit small, sour; not of the best quality.

Hand. — Tree a large, strong grower; shapely; notably unproductive. Fruit large, fine, showy. This variety is certainly not worth planting, the objection being its unproductive character.

Lincoln. — Tree not very strong or sound, and fruit not of very good quality. Not to be recommended, on the basis of our experience.

McLaughlin. — Tree unhealthy and a poor grower; not bearing very heavily. Fruit not so smooth and highly colored as in some sections, but still of very fine quality. In spite of its imperfections of tree, this variety is worth growing on account of its high quality; it would not be profitable in a market orchard.

Moore's Arctic. — Tree vigorous, upright, strong, hardy; productive, and coming fairly early into bearing. Fruit small; rather poor quality.

Peter's Yellow Gage. — Tree not very vigorous or hardy; a slow grower. Fruit small, and not very good for this variety.

Pond. — Tree large, strong grower; fairly productive. Fruit large and excellent, but very much subject to rot, and unprofitable on that account.

Quackenbos. — A very good, medium-sized tree, fairly productive. Fruit medium size; clean and fair quality for one of the small blue plums. This is probably the best of the so-called blue plums, with possibly the exception of Englebert.

Reine Claude. — Tree an irregular grower; not very vigorous, and only moderately productive. Fruit medium size and quality for this variety; considerably subject to rot. This takes the place of the old-fashioned Green Gage, being a larger, better and later variety. It is a very fine plum for canning, but could not be profitably grown for the market in this locality.

Saratoga. — Our single tree of this variety is small, and not very productive; unpromising.

Smith's Orleans. — Tree moderate size, somewhat irregular in growth; moderately productive. Fruit not so large or fine as it should be in this variety.

Tragedy. —We have only one tree of this variety, just coming into bearing; promising.

Victoria. — Tree moderately large; irregular in growth; moderately productive. Fruit of medium size and excellent quality; somewhat subject to rot.

Washington. — In almost all respects like Hand, which see.

Japanese Varieties.

Abundance. — Tree upright, early bearing; very much subject to disease. This is probably one of the poorest trees to be found amongst the Japanese plums. Fruit of good size and good quality; somewhat subject to rot; very apt to be eaten by birds. We would entirely discard this variety as a commercial plum, on the basis of our experience, and could not recommend it highly for planting for home use. This experience we are aware is different from that of some other plum growers in New England.

Burbank. — Tree vigorous, spreading, hardy; comes early into bearing, and is very productive. Fruit medium to large, good quality; less subject to rot than most plums. This is the most profitable and productive market plum on our grounds.

Chabot. — Tree upright, vase form; hardy, prolific. Fruit medium size, round red; fair quality. This is an excellent market plum, medium to late in season.

Georgeson. — Tree spreading, rather large growing, vigorous and hardy; fairly prolific. Fruit large, yellow; good quality. This is an excellent canning plum, and worth growing in this section, although it does not sell well in the markets on account of its yellow color.

Hale. — Tree upright, very vigorous grower; somewhat subject to winter-killing; coming rather late into bearing, never bearing abundantly. Fruit medium size, round; excellent quality. According to our experience, this variety is not worth planting in this section.

October Purple. — Tree vigorous, upright, and very strong grower; somewhat subject to winter-killing; coming late into bearing, but giving moderate crops after reaching an age of seven or eight years. Fruit medium size, rather dull color; good quality. The variety does not seem to be of any special value in this section.

Paragon. — Somewhat like Chabot, but of no special value.

Red June. — Tree spreading, vase form; vigorous and relatively hardy. The fruit buds on this variety are less hardy than on Burbank, however, sometimes being killed while Burbank survives. Trees bear early and abundantly. The fruit is one of the first to come into the market, and, though of second quality, usually brings a fair price. This is proved to be a profitable plum with us.

Satsuma. — Tree upright, spreading, moderate grower; not very hardy, bearing rather sparsely. Fruit usually small with us; of indifferent quality. Although this variety succeeds in other localities in the Connecticut valley, it is of no value here.

Hybrid Varieties.

Apple. — Tree very vigorous, sprawling grower; hardy, coming fairly early into bearing. Fruit medium large, round; dark red with red flesh. On our grounds this variety promises to take the place of Satsuma, to which it seems to be superior in most respects.

Compass Cherry. — An interesting hybrid curiosity, but of no value.

Doris (doubtfully placed among hybrids). — Tree spreading, vigorous, hardy. Fruit small, watery; of no value.

Duke. — Tree medium strong, upright; fruited this year for the first time; of doubtful promise.

Gold (of Stark Brothers). — Tree small, spreading, irregular in growth; hardy, bearing early, but never abundantly on our grounds. Fruit round oblate, medium size, yellow, watery; poor quality, ripening very unevenly; much subject to rot. This variety is of no value with us, and our trees have been mostly grafted to other sorts.

Juicy. — Tree strong and hardy. Fruit small, yellow; of no value.

Wickson. — Tree upright, strong grower; rather tardy in coming into bearing, and never bearing heavy crops; fruit buds tender, apt to be frozen. Fruit of medium size, variable in quality; ripening very irregularly. This variety is not to be recommended here.

Native Varieties.

There are on the grounds several native varieties, mostly Americanas, Hortulanas and Chickasaws. Some of these do fairly well, but none of them have conspicuous merit as grown in this section.

Marketing Plums.

The very excellent crop of 1904 gave us an opportunity to study the manner in which plums can be sent to market. For the most part the crop from the department of horticulture of the Massachusetts Agricultural College was marketed in three-pound baskets, such as are used for grapes;

when these were shipped by freight or express, they were packed in crates holding approximately one bushel. This style of package proved generally satisfactory; it furnishes about the quantity of fruit desired by most purchasers.

In making local sales, especially of plums for canning purposes, a larger package was usually more satisfactory. The so-called Jersey peach basket, holding sixteen quarts (one-half bushel), is the cheapest and most convenient.

In some cases, where fancy plums are designed for the fruit stand trade, they may be put up in quart baskets, such as are used for strawberries. We find these also satisfactory.

This whole matter may be summarized by saying that most markets are not fastidious with respect to the form of package used for plums. Any small, neat basket or box will answer, if the fruit is of good quality and well packed.

Experiments in Pruning Peach Trees.

The department of horticulture has under way a series of experiments and special studies in pruning fruit trees. Reports on various phases of this work will be made from time to time as results are reached. At the present time we are able to make a report of progress in the experiments in pruning peach trees.

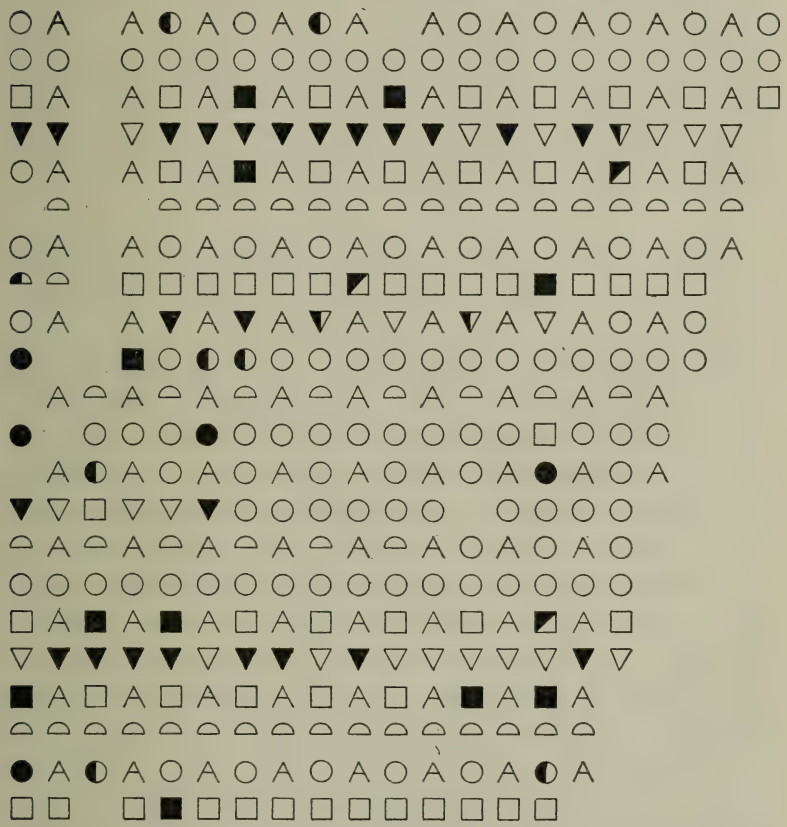
1. The Results of No Pruning.

One row of trees in the principal peach orchard has been left entirely without pruning from the first. This row runs crosswise of the variety rows, and therefore contains trees of all the varieties in the orchard, as follows: Oldmixon, Triumph, Mountain Rose, Elberta, Early Crawford, Late Crawford, Crosby. The trees are nine years old.

These trees, left unpruned for nine years, are plainly different from adjacent trees of the same varieties which have been pruned. Surprising as it may appear on first statement, they are more open-headed. They have generally assumed a vase form. The interior wood has died out, leaving the centres open, and at the same time leaving the lower part of the main branches bare. The fruiting wood is sparse, weak and high up in the trees. The trees are very

much less thrifty and vigorous than the pruned trees of the same varieties. This lack of vigor is so marked that some of the weak trees succumbed more or less completely to the severe freezing of last winter.

The trees next the unpruned specimens have been headed back two or three times. They were all headed back mod-



MAP OF EXPERIMENTAL ORCHARD. — A shows apple trees 40 feet apart; the circles show peach trees unpruned; the half-circles show those slightly headed back; the squares indicate trees severely headed in; the triangles show trees cut back to stubs; the blackened figures represent trees which died in 1904.

erately in the spring of 1902 and again in the spring of 1903, and some of them were headed back again in the spring of 1904. The trees so treated are thick-topped, with a good deal of weak, sappy growth on the inside, — a condition which is manifestly objectionable. On the other hand, the

annual growth has been much more vigorous, and the health of the trees has been much better. More and stronger fruit buds have been formed, but unfortunately the successive freezes of the last two winters have killed the buds, and made a comparison of fruit crops impossible. The main branches of the headed-back trees are shorter and stronger than those of the unpruned trees, and are obviously better able to support a large crop of fruit.

This experiment, which was begun by Prof. S. T. Maynard, and which has been continued through several years, has shown conclusively that the best form of peach tree cannot be secured and maintained without pruning.

2. *The Effect of Heading Back.*

Each spring, in the years 1902, 1903 and 1904, a number of trees in the college peach orchards were headed back. This shortening-in of the branches varied in amount: sometimes only one-third of the previous year's growth was cut away, sometimes one-half the year's growth was taken off, sometimes two-thirds was removed; in a few cases the trees were pruned clear back into two or three year old wood; in the majority of cases the heading-in amounted to about two-thirds of the previous year's growth. The cutting back in 1903 and in 1904 was more severe than it would have been had not the prospective fruit crop been wiped out by freezing.

In nearly all cases it was possible to compare trees thus headed in with other trees of the same varieties not so treated. The results were uniform and unequivocal. The trees headed back always made a more healthy and vigorous annual growth than the trees not so treated. In many cases the difference was remarkable, the growth of the pruned trees being from two to ten times as much as the unpruned trees. More and larger fruit buds formed on the pruned trees, and the shorter, stockier branches seemed better prepared to support a possible fruit crop. The foliage on the pruned trees was notably larger, more abundant and darker green. There was some tendency to the formation of weak shoots on the shaded interior branches.

The conclusion which we have reached from this experiment, continued through three years, is that the heading back of peach trees in early spring is good practice, and in all cases advisable. In this pruning from one-third to two-thirds of the wood of the previous year should be removed. In determining the exact amount to be cut away, the judgment of the fruit grower will be influenced largely by the number of living fruit buds in the one-year-old wood. If there is a crop in prospect, he will leave enough fruit buds to set the desired quantity of fruit. In years when, from one cause or another, there are no living fruit buds, he will take advantage of the circumstances to cut back with comparative severity. Only in extraordinary instances, however, will he remove all the previous year's wood, cutting back into two or three year old branches.

3. Summer Pruning.

It has been noted above that trees which were headed back in the early spring pruning showed a tendency toward the formation of many weak and useless shoots on the interior of the head. Experiments in summer pruning were begun with a view to the correction of this tendency, and also with a view to stopping the really inordinate extension of the main annual shoots of the current year. The two problems, however, were met in different ways.

The formation of weak sprouts on the interior of the tree is due chiefly to the exclusion of light. The external foliage of the tree top becomes so dense that the interior is shut off from the light and from much of the air. To improve the situation in this respect we have gone through the orchard once or twice between the middle of June and the middle of July, removing a considerable quantity of the new leafy shoots on the outside of the tree. A quantity of the outside shoots and foliage was thus removed sufficient to admit a reasonable amount of light to the inside of the tree top. The work was done with a pair of hand pruning shears, or, when the branches were soft, they were simply torn out with the bare hands. The latter method is preferable, because more expeditious.

In no case were the results of this treatment convincing. The formation of strong shoots with fruit buds on the interior branches was never visibly promoted. The outside branches which were allowed to remain seemed to profit somewhat by the removal of their crowding neighbors, and this was apparently the chief benefit derived from the work. On the whole, it does not seem to us that this practice is to be greatly recommended.

To correct the over-growth of outside branches, the plan was tried of cutting back the young growth. The tips were pinched or the shoots were pruned with hand pruning shears. Sometimes a foot or so of new growth was removed. The pruning was done at various seasons, usually some time in July.

In all cases this treatment was unsatisfactory. The stopping of the growing shoots is often — almost as a rule — followed by the pushing of side buds, and the shoots thus formed are nearly always too weak to set fruit buds, yet in putting out they ruin what might otherwise become strong, sound fruit buds.

4. Pruning to renew Frozen Trees.

As the spring of 1903 drew on, it was plain that more or less injury had been suffered by the trees in our peach orchards. In the spring of 1904 the damage was still more obvious and widespread. In both years some experiments were made to learn the best manner of handling a winter-injured tree.

The damage in the spring of 1903 proved to be small, and measures designed to have a corrective effect therefore showed meager results. All the trees came off about equally well, no matter how treated. Some were lightly headed in, some were severely headed in, while a few were cut back nearly to the main trunk, leaving only the stubs of the main branches. In every case not otherwise to be accounted for the tree recovered and made excellent growth.

In the spring of 1904 the trees were seriously weakened by freezing, and some were killed outright, so as to be beyond the reach of any remedial treatment. It should be said, however, that the damage proved to be less sweeping

than was feared at the time the year's experiments were outlined. It was decided to lay off the orchard where this experiment was to be made into four blocks, to be given different kinds of treatment, as follows: (1) the first block was to be left entirely without pruning; (2) the second block was to be pruned in midsummer, after the trees had started; (3) the third block was to be cut back, from two-thirds to three-fourths of the previous year's growth being removed; (4) the fourth block was to be headed back near to the trunks, only the stubs of the main branches being left.

A certain percentage of these trees died during the year of 1904. The general result can be seen in the following table: —

Statistical Summary.

	Total Number pruned.	Living, Autumn of 1904.	Dead, Autumn of 1904.	Per Cent. Living.
Trees unpruned, ...	121	113	8	93
Moderately cut back, ...	48	47½	½	99
Severely cut back, ...	68	55	13	81
"Dehorned,"	46	24	22	52

It will be seen that the trees cut back to the trunks ("dehorned") suffered the worst; those severely cut back lost a larger percentage than those unpruned. A careful examination of the orchard itself makes it seem that the difference between blocks 2 and 3 in this respect is considerably exaggerated by the statistics. Some of the deaths in block 3 were apparently due to other causes, and should not be charged up against the pruning. Moreover, the growth made by the headed-in trees which lived was decidedly better than that made by the unpruned trees. The judgment of all those who saw the orchard and examined it carefully during the latter part of the summer of 1904 was that the trees moderately cut back showed the best growth and were in the best condition.

It at least seems clear that the trees seriously weakened by freezing should not be cut back close to the main trunks.

Growing Chrysanthemums for a Retail Trade.

By Francis Canning.

The work in the college greenhouses has to a certain extent been carried along on the lines and in many respects similar to that of a country florist's establishment, having a local trade. The many problems which present themselves under such conditions have been the subject of considerable experiment.

A florist's establishment in a country town is managed on a very different basis from that which obtains in growing cut flowers for the wholesale market, where two or three varieties of flowers are grown in quantity.

To meet the demands of a local trade requires the handling of a large variety of cut flowers and plants, not necessarily large in quantity, yet sufficient to meet the demand when any particular variety is in season.

One of the principal crops a florist grows under such conditions is the chrysanthemum, and it necessarily follows that he must be familiar with the earliest and latest flowering varieties, so as to prolong the season as far as possible. He must also ascertain which varieties are the best adapted for pot plants, also the colors which suit his trade.

The chrysanthemum having a short season, it follows that considerable forethought is necessary in the arrangement of space devoted to it; it frequently means the crowding of some other crops until that occupied by the chrysanthemum becomes available. To the uninitiated the transformation at the close of the chrysanthemum season, from beds filled with blooming plants to those occupied with other material, seems remarkable; yet the florist has long prearranged this matter in his mind. At this stage the saving of the necessary stock plants is done. In this connection a weeding out of undesirable varieties, or varieties that do not reach the standard in the grower's judgment, is accomplished. Various methods of saving the stock plants are practised; but we have found the use of boxes five or six inches in depth, with provision for drainage, to be a good method. It is better, however, not to mix several varieties in one box, for even though

placed separately, the creeping stems will invade each other's territory, and result in mixing the varieties when the cuttings are taken. The boxes should be afforded a reasonably good place in a cool greenhouse, where the sun may reach them, so they do not have a soft, spindly growth, a condition exceedingly detrimental to future success.

Propagating commences in February, or much earlier when any special variety is to be considerably increased. After two batches of cuttings have been rooted, the boxes containing the stock plants may be thrown away, depending upon the newly propagated plants for future cuttings. From the earlier-rooted cuttings the varieties suitable for pot plants are selected, and are potted on as their needs demand. For the general stock for benching, or, in other words, for the cut flowers, the best time to propagate is from April 15 to May 1; thus suitable provision is made to have strong plants in two and one-half or three inch pots by the time the season arrives for planting. No specific date in this connection is observed, some florists commencing to plant in May and others late in July; but when the propagating has taken place at the previously mentioned date, the plants will be in good condition from the 15th to the end of June.

The question as to the advantages of solid beds or benches is of some interest. Our experience has been in favor of solid beds. We are, however, favored with a soil of a porous character, and gravelly subsoil, which for solid beds insures a good drainage, — a necessity for this crop. Wherever one may secure similar conditions, it would seem advisable to adopt this method, and thus avoid the expense of building benches and keeping them in repair.

The young plants are planted in rows eight inches apart each way, allowing two or three shoots to form, and thus secure the same number of blooms from each plant.

The soil used for benches and pot plants is a good, turfy loam, and is composted the previous fall or in the early spring of the same year. To three parts of soil is added one part of well-rotted manure, with bone meal to the amount of one quart to the barrowful of compost. To avoid fungous diseases, keeping the plants in good health by careful culture

is the best preventative. For disposing of the ever-present aphis, or black fly, fumigation with tobacco has proved the surest and cheapest remedy. Throughout the year chrysanthemums should be subjected to a weekly fumigation, the prevention of insects being especially desirable in their successful management.

About forty varieties of chrysanthemums are grown in the college greenhouses, many of them represented by a few plants only, to ascertain their merits for such a trade as ours. This method of becoming acquainted with newer varieties should be adopted by all progressive florists. The fact remains, however, that many older varieties have not yet been superseded. Not infrequently the size of bloom has been the principal point in favor of the newer introductions, sacrificing in some instances their purity of color.

The following varieties have proved themselves well adapted for a local trade, being easily grown and naturally vigorous. In their order of flowering they are: white, — Polly Rose, Ivory, Alice Byron, Queen, Timothy Eaton, W. H. Chadwick, Merry Christmas; pink, — Glory of the Pacific, Pink Ivory, George Carpenter, Mrs. Perrin, Mrs. C. F. Berwind, Mrs. S. T. Murdock, Maud Dean; yellow, — Sinclair, Robert Halliday, Colonel Appleton, Major Bonaffon, W. H. Lincoln, W. H. Reiman; bronze, — Brutus, Sunrise, Petaluma; red, — Gettysburg, Malcome Lamond, Cullingfordii. The varieties that do well as pot plants are: Ivory, Alice Byron, Pink Ivory, Mrs. Perrin, Mrs. S. T. Murdock, Mrs. C. F. Berwind, Sinclair, Major Bonaffon, W. H. Lincoln, Brutus, Sunrise, Cullingfordii.

The singles and pompons should not be overlooked. They may be grown in pots with very little disbudding. They have a wide range of colors, and make salable pot plants; the white ones afford good material for designs, etc. Among the best may be mentioned Snowdrop, President, Julia Lagravere, Queen of England, Mizpah, Buttercup.

A great aid in the matter of testing the qualifications of varieties is the use of the "scale for judging" adopted by the Chrysanthemum Society of America. In scaling a variety a searching investigation is made, and many defects are

apparent not ordinarily observed. In the work of the class in floriculture in the Massachusetts Agricultural College special emphasis has been placed upon judging chrysanthemums. Some practice will soon develop a rapid and correct estimate of the merits of varieties, and should prove valuable to the average florist.

The commercial scale is as follows: —

Color,	20	Substance,	15
Form,	15	Size,	10
Fullness,	10		
Stem,	15	Total,	100
Foliage,	15		

The score upon a number of varieties follows: —

Major Bonaffon.		*The Queen.*	
Color,	18	Color,	15
Form,	12	Form,	10
Fullness,	10	Fullness,	6
Stem,	15	Stem,	15
Foliage,	15	Foliage,	10
Substance,	12	Substance,	8
Size,	10	Size,	10
Total,	92	Total,	74

Black Hawk.		*Colonel Appleton.*	
Color,	20	Color,	20
Form,	7	Form,	12
Fullness,	10	Fullness,	8
Stem,	7	Stem,	13
Foliage,	12	Foliage,	10
Substance,	8	Substance,	12
Size,	8	Size,	10
Total,	72	Total,	85

These scores may vary from those awarded the same varieties by the Chrysanthemum Society of America. Our conditions may be accountable for the variation.

Some varieties present features especially desirable for a retail trade, — good keeping qualities, oddities in shape or color, etc. Those presenting desirable features, from two or three years' tests, follow: —

Baer, Mrs. G. F. — Known as Yellow Jerome Jones, and presents many of the fine characteristics of this fine variety.

Berwind, Mrs. C. F. — Dark pink, with silvery reverse; good keeper; a desirable kind.

Black Hawk. — Dark crimson; one of the handsomest of this color, and should be grown where there is any demand for this color.

Brutus. — Orange red; very dwarf in character; makes good pot plant and cut flowers; a desirable color, and satisfactory.

Byron, Miss Alice. — One of the best whites; makes a fine pot plant, and good for cut flowers.

Carpenter, George. — Medium early, dark pink flower; there is a demand for this variety when well grown.

Childs, G. H. — One of the best dark reds for cut flowers.

Dean, Maud. — One of the best pinks; large flower, good shape; fine for Thanksgiving trade.

Golden Trophy. — A desirable kind for pot plants.

Idavan. — Fine solid pink flower, shading to cream; a few are desirable.

Intensity. — Red; a good pot plant.

Jones, Mrs. Jerome. — One of the best whites.

Liberty. — A good late yellow; grown cool, will last till Christmas.

Merry Christmas. — A correspondingly late white variety.

Millbrook. — An odd salmon pink; a few pot plants may be serviceable.

Murdock, Mrs. S. T. — A desirable kind for cut flowers and plants; shell pink in color.

Mutual Friend. — A good white variety.

Petaluma. — An odd quilled-petalled variety; bronze or brown in color; good keeper.

Philadelphia. — Lemon yellow; globular flower; good for fancy trade.

Pitcher, Miss Georgiana. — A good old robust yellow variety, easily grown.

Reiman, W. H. — Yellow globular; late, good for Thanksgiving and later.

Rose, Polly. — An indispensable early variety.

Sunderbruch, H. L. — An early yellow; fine large flowers; good for pots.

Many other prominent varieties are being tested, a second year being desirable, to determine their value.